

Fifty More Years Below Zero

Fifty More Years Below Zero

Tributes and Meditations for the Naval Arctic Research Laboratory's first half century at Barrow, Alaska

DAVID W. NORTON, EDITOR

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DEDICATION

Contributors to this volume dedicate it, not to an individual, but to the spirit of collaborative inquiry in pursuit of understanding the natural world. This collaboration is exemplified herein by that between the late Harry Brower, Sr. and Dr. Tom Albert. Contributors hope that this collaborative goodwill continues to distinguish the combined futures for arctic science, science support facilities, and the hospitable communities of Alaska's North Slope.

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FOREWORD

Maxwell E. Britton¹

The Naval Arctic Research Laboratory (NARL), at first lacking the military reference in the name and known simply as ARL, represents one interesting episode in the remarkable saga of the Office of Naval Research (ONR). That parent organization came into being in 1946 and still exists as a vital research entity just across the Potomac River from Washington D.C. in Arlington Virginia. The establishment of ARL followed in 1947 (Britton; Schindler, this volume) but did not enjoy the longevity of ONR and was closed out in 1980. The NSF came into being four years after ONR and has played a long and honorable role in polar research with the Antarctic dominating the program. In 1969, the Vice President of the United States, Chairman, National Council on Marine Research and Engineering Development, named NSF as the lead agency for arctic research (Colwell, 1987). This action presaged difficulties, at least in the long term, for ONR participation in the broad-spectrum research characteristic of its Arctic Program.

In the pages of this volume the reader will find some detail of the history of NARL; a gratifyingly large representation of scientific work accomplished; the story of the acquisition of the Laboratory complex by the Iñupiat people; the continuation of arctic research under their sponsorship; and a sampling of their scientific achievements resulting from both their own research projects and the support of that of other individuals and agencies.

That NARL should deserve and receive celebration of fifty years of mixed military and civilian contributions to the benefit of the people of the United States came to me as no surprise. What did surprise me was the applaudable fact that the idea and its implementation originated among the Native people, the Iñupiat Eskimo

people, of the North Slope Borough of Alaska and proceeded under the specific aegis of the Barrow Arctic Research Consortium (BASC). This group working, it is understood, with the assistance of a few resident staff and outside scientists, had proceeded quietly and persistently with the planning of a celebration for at least a year before more than rumors reached me. It proved to be a very happy and successful event at NARL in August 1997—the occasion for which this volume constitutes the much augmented, enhanced and, frankly, greatly improved proceedings.

In due course, formal announcement of the proposed 1997 meeting at Barrow reached me. Included was a list of possible speakers with topics the individuals might address. My name was included with the suggested title as appearing in my brief historical paper of this volume. Preceding mine, another similar paper (Schindler, this volume) refers to the oil exploration program of Naval Petroleum Reserve No.4 and the attendant earliest days of NARL's history within the logistics support system of that operation.

My first reaction to preparation of a paper on the role of ONR had been to suggest both question and answer were naïve and unnecessary. NARL sprang from the fertile minds of ONR scientists for the sole use of its contractors, grantees, or any other research the Chief of Naval Research found meritorious of his approval. That said it all. Then it occurred that my reaction was perhaps a bit arrogant; the *cognoscenti* of arctic science certainly knew the facts but the proceedings of the celebration were planned for publication and would reach a much wider international audience lacking knowledge of the total meaning of NARL.

So, in the interests of history and clarification, the simple message was put to paper. Now, three years later, as this foreword is completed, it suddenly dawns on me that there is yet other reason to elaborate on

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roles in NARL's development. It is an existent entity still bearing a Navy name but having no current relationship to the U.S. Navy. Iñupiat people who knew the old NARL speak of it with fondness and respect and probably cannot even contemplate changing its name. The editor's introduction (Norton, this volume) presents a thoughtful review of the persistence of the NARL name. It would be interesting to know how many maps and charts have borne the name since the Navy surrendered control and how many publications have given honor to the name by citation.

It was a great pleasure to participate in the celebration as writer, listener, discussant, and simply as visitor with large numbers of men and women of distinction in arctic sciences. It was a time of intense reunions and reminiscences of happy days gone by and of enjoyment of the generous hospitality of the conveners of the conference as well as of the Iñupiat population at large and of the NSF. I had known many of the participants throughout the years of my research and administrative roles at NARL. Some had been babies during my earliest years there and on this occasion, about 45 years later, there were many surprises. The surprises were for the most part happy ones but inevitably there were moments saddened by ravages of time and illness and the knowledge of those who had passed away.

The meeting, titled "Science in the Community," celebrated the scientific interests of the Iñupiat people as reflected by direct contributions to various research projects and by support to the research of others. Participation in research is perhaps best illustrated by the well-known collaboration of Simon Paneak with Larry Irving but there are numerous examples of other consultations and information sharing. Evidence of research and research support is everywhere as the local people have been generous in bringing to their community many scientists who have led, taught and joined forces with them to do research.

It appears to me that the greatest influence on development of Iñupiat research came as a consequence of Dr. Thomas Albert's organization of the Department of Wildlife Management where, after many years of intense, productive research, he remains as Senior Scientist. Surely, he must be pushing Max Brewer, longtime Director of NARL, for bragging rights for length of tenure in service to science at Barrow. Albert gave an excellent paper on his research and management roles and I, for the first time, began to grasp the scope and importance of the research and leadership of this respected arctic scientist. The nature of his bowhead whale studies became clear to me for the first time and

the amount and quality of Iñupiat participation more fully appreciated. Recently I have been privileged to read his excellent revision (Albert, this volume) of that paper and to become even more appreciative of what seems the indispensable role of Harry Brower, Sr., a longtime NARL employee, in planning, guiding and participating in the bowhead whale research program.

Program planning for the celebration appears to have had considerably less scientific content initially than that which gratifyingly emerged in the final program. There were signs that some urging by staff scientists was necessary to present a well-balanced representation of research accomplishments over the full life of NARL. No such meeting, however, can ever do full justice to all programs or be inclusive of all scientists who participated over the years. My own thoughts at the meeting dwelled a great deal on other people who should have been present but were not; there are so many of them. Some of those not present had probably been invited to attend but were not able to do so. In the interim between the presentation of papers at the conference and the impending publication of the proceedings, several papers have been added from persons who did not attend the meetings. In other cases, papers given in 1997 have been expanded for this publication.

I personally found one source of disappointment with the 1997 program to be its lack of discussion of the historic events of the interval between the closing of NARL by ONR and the full takeover by the Iñupiat community leadership. Happily, BASC and the editor have corrected this situation by the stimulation of new and noteworthy articles that bear importantly on both history and science of that period (Albert; Burns; Kelley and Brower; Norton; and Quakenbush, this volume). A gap remaining in the history of NARL is that of the period of its later years when operating as a Navy Facility. This honorable story should be recorded, but I am assured by the editor that it must be left for another day.

All who attended the celebration will recall that a major objective was to remember, review and honor the contributions made to NARL research by the Iñupiat people. Further, two gentlemen, Mr. Kenneth Toovak and Dr. Max C. Brewer, were accorded the distinction of special honors. When Kenny stood before the audience accepting his honor, he surprised all by making a little speech expressing how many other people he believed deserved to share in his honor. I was humbly touched when he invited Max Brewer, John

Schindler, several others, and me to stand with him and share what was clearly well deserved honor earned by his talents alone. To me, he exhibited the best of intelligence, pride, humility and modesty representative of his people.

The foregoing paragraph was written, in October 1998, when I had just recently returned from a meeting of the American Polar Society (APS) at the Byrd Polar Research Center on the campus of the Ohio State University. The APS, dormant for several years, was reactivated under the leadership of Brian Shoemaker, Secretary and its Board of Governors. The Columbus Symposium was the first convening of the members since the reactivation. Many will remember Captain Brian Shoemaker, U.S. Navy Ret., as one of the commanding officers of the NARL Naval Facility.

Captain Shoemaker had organized the Columbus meeting and was its General Chairman. Here APS honored a large group of eminent arctic and Antarctic scientists and administrators by award of Honorary Membership in the Society. Several of these were gentlemen who had long association with NARL. These included Norbert Untersteiner, Max Brewer, Beaumont Buck, Wilford Weeks and Kenneth Toovak. On this occasion, in an elegant banquet venue, each honoree was escorted to the dais to be introduced, to receive a beribboned APS medallion, and to make a few appropriate remarks.

In his turn, Kenny was introduced, the ribbon bearing the pendant medallion was draped around his neck, and he turned to the microphone to make his remarks of acceptance. Characteristically, once again he did so in his own inimitable dignity and style, first sharing his honor with persons present whom he sincerely believed should be at his side and be recognized. He called to join him at the dais, two with NARL administrative history, Max Brewer and John Schindler, and two from ONR history, Ronald K. MacGregor and myself. For this sincere, thoughtful and very charitable act, coming in addition to the recognized personal merits of his well-deserved honor, Kenny received the most generous spontaneous ovation of the evening and became the subject of much of the after dinner conversation.

Other Iñupiat participants witnessing the ceremonies were the Honorable Benjamin Nageak, Mayor of the North Slope Borough, and Richard Glenn, President of BASC. Mayor Nageak also presented an invited paper at one of the formal program sessions. In the course of his discussion of “3000 Years of Exploration in the Arctic,” he emphasized the significance of NARL in the

development of his knowledge and attitudes toward the importance of science and education in the community. Ben has been, and remains, an active force in state and local governments in Alaska in promoting the educational and research interests of his people.

During the summer of 1998, BASC reported that the proceedings of the meeting would in fact be published, as had been promised, that editing was proceeding in the capable hands of Dr. David Norton, and that he anticipated the collaboration of Dr. Karen McCullough, editor of the journal *Arctic*, the well-known and widely respected organ of the Arctic Institute of North America (AINA). Further, it was announced that BASC publication plans provided for inclusion in the proceedings, the AINA-generated volume of special letters to Mayor Ben Nageak, presented to him as part of the 1997 celebration. Those letters were solicited by the U.S. Corporation of the AINA under the leadership of Dr. John Kelley. Those who responded were very diverse in their relationships to NARL and all contributed well to the manifold aspects of its life and times. In fact, there is perhaps more good and interesting history of the Laboratory in them than in the formally planned conference agenda. Although a copy of this history-rich volume of letters was presented also to the University of Alaska Fairbanks Library, BASC is to be complimented for making them more widely available by publishing them here.

At the same time I learned of those developments I was offered the opportunity to prepare a foreword for the proceedings. At first I was reluctant to accept the proffered role. It had been 28 years since having direct involvement in NARL science and anything I had to say had long-since been said and re-said. I shall give two examples of often-repeated bits of NARL lore.

One story I often repeated when defending Arctic Program budgets, and which others repeated in various contexts, was meant to illustrate the importance of serendipity in basic research. It was the quite unexpected discovery of the Barrow Sea Canyon in the Chukchi Sea off Point Barrow. Two marine biologists, George and Nettie MacGinitie, discovered this deep canyon in 1949 while collecting bottom organisms from the sea floor (Feder, this volume). Dr. Waldo Lyon and associates of the Navy Electronics Laboratory later mapped the canyon in detail, realizing its potential importance as a deep-water, under-ice route for submarines from the shallow Chukchi Sea into deep water of the Arctic Basin (Fig. 1). George MacGinitie for a short time was the second director of NARL (Schindler, this volume). The Barrow Sea Canyon has

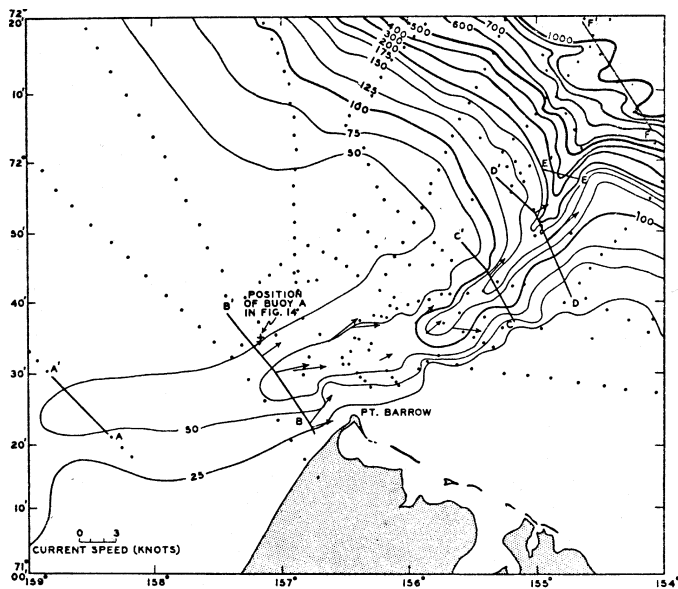


Fig. 1. Chart of the Barrow Sea Canyon carried on the Nautilus (SSN 571) in 1958, during the nuclear submarine's historic transit of the Arctic Ocean. Source: Leary, 1999; reprinted with permission, Texas A&M University Press.

been used a number of times by nuclear submarines. Waldo was probably aboard all or most of those submarine transits of the canyon, monitoring his instruments. The recent biography of Waldo Lyon richly reflects his works and exploits with arctic submarines (Leary, 1999). It is an excellent book that is recommended reading for its scholarship and lively anecdotes, one of which was a “cloak and dagger” incident involving Waldo, a naval officer companion traveling incognito, and Max Brewer at Barrow (Leary, 1999: 118-20).

The second often repeated statement came to my attention in early 1999 when I was reviewing a very interesting draft document concerned with present and future research at NARL and environs (ARCUS, 1999). Now that it has been printed and distributed people can appreciate its elegant and excellent analysis and recognize it as closely related in many ways, both by people and content, to the 1997 BASC celebration of NARL. It is highly recommended reading for its succinct reviews of history, the present status of research in the Barrow area and recommendations on future facility and research needs. The familiar phrase (ARCUS, 1999, p. 6) which drew my instant recognition was, “... a Canadian government official with long arctic experience observed that the assistance the DEW Line received from NARL saved the Air Force more money than had been spent on NARL and its research programs to that time.” To the best of my knowledge, the identity of that government official has never been revealed, at least in print, although there is no reason for

withholding his identity. This seems a good place for the gentleman, now deceased, to be saved from continuing anonymity in this matter. He was Commodore O.C.S. Robertson, Royal Canadian Navy, who accumulated many years of arctic ice and other oceanographic experience and who developed an enviable record of achievements.

In 1954, Captain Robertson, as the first commanding officer of H.C.M.S. *Labrador*, took his ship on her maiden voyage in circumnavigation of North America. This four-month cruise with research goals and many other tasks, took a course from Halifax, Nova Scotia through the Northwest Passage, the Beaufort, Chukchi and Bering Seas and ultimately back to the port of origin via the Panama Canal (Armstrong, 1955a,b; Leary, 1999: 72). As will be discussed further, a highlight of the cruise was the joint research program with the United States Navy, one of several such endeavors that brought Captain Robertson into working relationships Waldo Lyon.

Robbie, as his friends knew him, was often a member of AINA advisory committees and a sound source of advice for ONR research programs and other matters. I enjoyed two flying trips with him and others to parts of Greenland, Canada and Alaska. One of these two trips (there were others) was organized in 1959, not by the ONR Arctic Program, but as the responsibility of another ONR office that had a committee studying certain classified military matters. This was a working group trip to which both Max Brewer and I were invited participants although not officially involved in the classified study. The first destination was NARL in order to introduce the group to the laboratory operation and the then current ONR programs of research and to enable Max Brewer to join the group for the remainder of the trip to sites in Canada and Greenland. It was here at NARL, in one of the working sessions of the committee of which he was a member, that Robbie made the much quoted statement about NARL research resulting in large savings to the DEW Line builders.

Commodore Robertson was a handsome man of imposing stature, dignity and poise, and was blessed with great good humor, as mentioned. After departing Barrow and about to pass from Alaska into Canada, Robbie announced our position. He further announced that as Canadians, he and Max Brewer (born in Canada and enjoying dual citizenship) would pass through the airplane's cabin to exchange U.S. dollars for “hard currency.” He also was fond of saying, “I’m just a knot-head sailor but...” as he was about to deliver a cogent statement. I never heard anyone call him that.

Robbie's advice was always in demand with reference to research matters in the Canadian North, arctic Alaska, and Greenland. During his active duty days, Canada enjoyed large gains of expertise in mapping, charting, and oceanographic studies, including sea ice. These investigations were often joint efforts with Waldo Lyon, utilizing icebreakers of both countries. The exercise of 1954, previously mentioned, is one example. In that summer, Captain Robertson worked the *Labrador*, on research and other Royal Canadian Navy tasks, through the Northwest Passage of the Canadian Arctic Archipelago to Viscount Melville Sound. Here he kept a late August rendezvous with two icebreakers from the United States. These ships, the U.S.S. *Burton Island* and U.S.C.G.C. *Northwind* (Armstrong, 1955; Leary, 1999: 72, 75, 76, 80-82) conducted their own research through the Chukchi and Beaufort Seas and continuing into McClure Strait and adjacent Canadian waters of the Archipelago before joining the *Labrador*. The three-ship operation performed a varied and successful research mission, first among the islands of the western part of the Archipelago, then through Prince of Wales Strait, around the south coast of Banks Island, and through the Beaufort and Chukchi Seas to the program's conclusion in late September.

Lyon was a civilian physicist who spent much of his career with the U.S. Navy Electronics Laboratory, starting long before the availability of nuclear powered submarines. He was a tireless promoter of under-ice submarine operations; was clearly the leader in the study of the submarine ice environment; in advice to designers on characteristics needed for under-ice navigation, surfacing through ice, ice location and detection and others. Among his many achievements was the development and hands-on use of the acoustic instruments necessary for precision navigation through sea ice. Fortunately, the Leary biography is available and makes fascinating the battles and frustrations and successes of his notable career. He probably was aboard every U.S. nuclear submarine that operated under the ice up to 1981 when he made his final cruise (Leary, 1999: 254) and the Navy is much the better for his dedicated services. He received many honors and was to have received an award at the APS ceremonies in 1998, but died suddenly in May before the October event, so that his award was made posthumously. Although he did not work at NARL, he was sometimes there and was accorded every courtesy and whatever assistance he needed.

My anecdotal linkage of Lyon and Robertson places them clearly within the body of significant NARL lore, although for very different reasons; Lyon for capitalizing on MacGinitie's discovery of the Barrow Sea Canyon and

Robertson for his pearl of wisdom about NARL's value in cost savings in arctic construction and operations. Beyond these bits of factual lore lie the more significant roles of these gentlemen in the Arctic with reference to both research and surface and under-ice operations. In attempting to present some insight into their individual and collective contributions, there has been my failure to recognize the indispensable skills and dedication of the commanding officers of ships supporting Waldo Lyon and of the eminent Canadian scientists who carried the research load on the ships under Robertson's command. Many on both sides were well known to me and are well remembered and some even conducted research at NARL. Should this volume come to their attention, they should at least find that, although unnamed, they are not forgotten.

Through the influence of Lyon, Commodore Robertson was invited in 1960 to accompany the under-ice patrol of the Northwest Passage and the Arctic Basin by the nuclear submarine SSN *Seadragon* (Fig. 2) under the command of CDR George P. Steele. This patrol seems to have been a bonus to Robertson for his years of cooperative research with Lyon and, according to Leary, a reward for his influence in expediting Canadian government clearance for operation of *Seadragon* in the waters of the Northwest Passage (Leary, 1999: 191).

Both Lyon and Robertson had important influences on ONR/NARL that should be mentioned. It is my personal conviction (admittedly impossible to prove) that they created in their respective governments such interest in opening up the Arctic Ocean for operations that they



Fig. 2. Waldo Lyon, Commodore O. C. S. Robertson, and Art Malloy on *Seadragon*, August 1960. U. S. Navy photograph. Source: Leary, 1999; reprinted with permission, Texas A&M University Press.

unknowingly, but subtly and clearly, created an atmosphere that made research, such as that of the ONR Arctic Program, easier of attainment. Budget increases, procurement of military aircraft and other expensive equipment and even authorization to do venturesome things, exemplified by research stations on drifting pack ice or ice islands, went hand in hand with the progress of under-ice submarine successes. I believe there is a positive legacy of these men to Alaska, to NARL and to the local people even though not always recognized or articulated. These two men bear no responsibility, subtle or otherwise, for the later downturn in NARL's fortunes. That downturn was due to the understandable and necessary shift of ONR research interests and resources to other geographic areas.

To the legacies of these men and those of ONR/NARL, this volume now adds a third, at least a legacy in progress. In the hands and operation of the local people, that progress at NARL is notable for both volume and high quality. The existing published record of all Barrow research, due to its sheer volume, could not be fully explored by the Arctic Research Consortium but through the energetic efforts of Dr. Jerry Brown, an excellent abridged bibliography is presented (ARCUS, 1999: 73-96). This volume, the ARCUS background and recommendations, the long term research base, the existing

facilities, a nucleus of continuing government programs and the resident staff all signify the attractive inducements for funding of persistent, growing research at NARL. Success of that research shall be our wish.

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Research on the Colville River Delta: Lab and Local Support

H. Jesse Walker¹

ABSTRACT: The delta of the Colville River occupies about 670 km² in the center of Alaska's portion of the Beaufort Sea. This deltaic environment is highly varied, including lakes, sand dunes, sand bars, mudflats, ice-wedge polygons, as well as distributary channels. Erosion and deposition, especially during breakup, are dynamic. Since 1973, the delta has been the site of Nuiqsut, one of the new villages on Alaska's North Slope.

Key Words: Colville River, Colville delta, Nigilik, Nuiqsut, Woods family

INTRODUCTION

The Colville River's delta is modest in size (only about 670 km² or 257 square miles) compared with deltas of the Mississippi (28 600 km²), Russia's Lena (30 000 km²), Yenisei (4500 km²), or Alaska's more southerly Yukon (3000 km²) river deltas. Despite its relative geological youth, the Colville River's delta grew large enough some thousands of years ago to incorporate nearly all attributes of larger deltas. Like those deltas, this river-mouth formation discharging to the sea became rich enough in all forms of wildlife resources—terrestrial, aquatic, marine and airborne—to attract early Inuit activities and trade, themselves dating back a few thousand years. By the end of the 20th century, this delta had also become the home for the modern community of Nuiqsut, and the site of production drilling by the petroleum industry.

The setting and geologic history of the Colville River contribute unique factors or determinants to this discussion of its delta. The Colville drainage area (Fig. 1) of 54 000 km² (20 700 square miles) is dwarfed by the drainage areas of the Mackenzie (1 766 000 km²), the Lena (2 424 000 km²) and the Yenisei (2 590 000 km²). Unlike these large rivers emptying into the Arctic Ocean, however, the Colville is not "exotic." That is, the Mackenzie, Lena and Yenisei rivers all rise well south of the Arctic Circle, and thus carry exotic or southern water from climatic and hydrologic regimes different from those in the Arctic. Because its drainage area is defined and bounded by the crest of the Brooks Range to the south, all of the Colville River's flow is from precipitation that fell within the Arctic Circle at some time in the past.

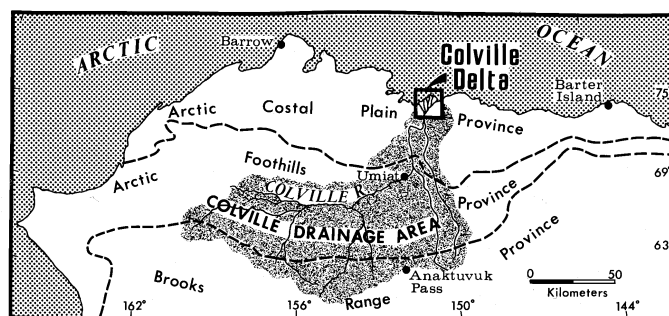


Fig. 1. Present-day Colville River drainage area and delta.

Among non-exotic arctic rivers, the Colville ranks as one of the longest. Its length is partly explained by the underlying geological structures that bound its upper and central drainage area (Fig. 2). The Colville flows predominantly in a geologic trough west-to-east along the Colville Geosyncline or the "Colville Basin" (Fig. 3), until it reaches the Chandler and Anaktuvuk rivers near the longitude of Umiat Mountain (152° W). At Umiat, the river turns north. Based on the reconstructed glacial history of the Pleistocene (Fig. 4), it is easy to imagine that the Colville once continued to flow farther

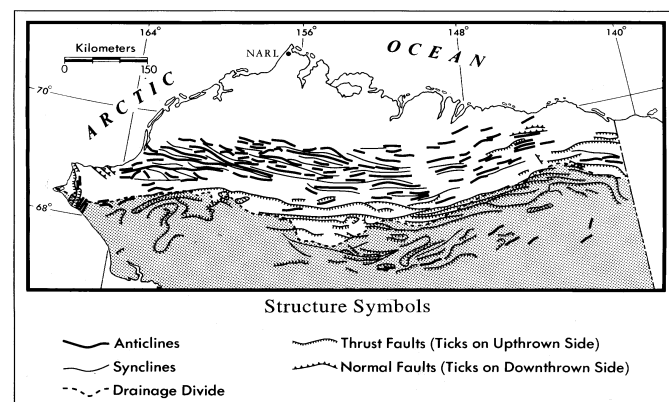


Fig. 2. Geological structures underlying Brooks and Arctic Foothills Provinces.

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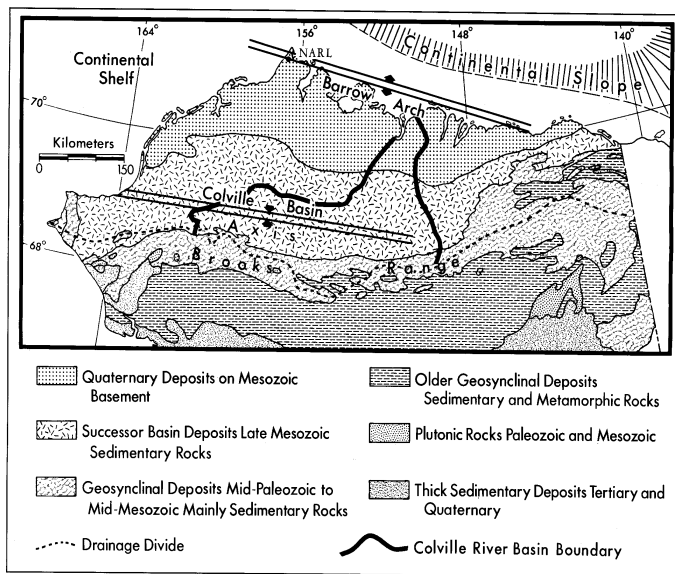


Fig. 3. Sources and geological ages of surface-evident formations, from the Brooks Range to the arctic coast of Alaska.

eastward in the geosynclinal trough parallel to the northern terminus of Brooks Range ice fields. Its water did not turn sharply north to empty into the Beaufort Sea until joining the Kuparuk, Sagavanirktok, or even Canning river drainages. In other words, the northward-turning arm of the Colville has moved steadily westward over geologic time, eroding through Mesozoic sedimentary deposits, taking an ever shorter route to the sea, and abandoning its former channels and deltas to the east. In its most recent westward migration, the Colville would have abandoned the Iktulik River (with which it still shares its delta and part of a floodplain) and before that the Kuparuk and its delta. From Umiat northward to the Arctic Coastal Plain at Ocean Point, the present course of the Colville pits the river's energy against the base of Mesozoic sedimentary bluffs and overlying Quaternary sedimentary deposits along its

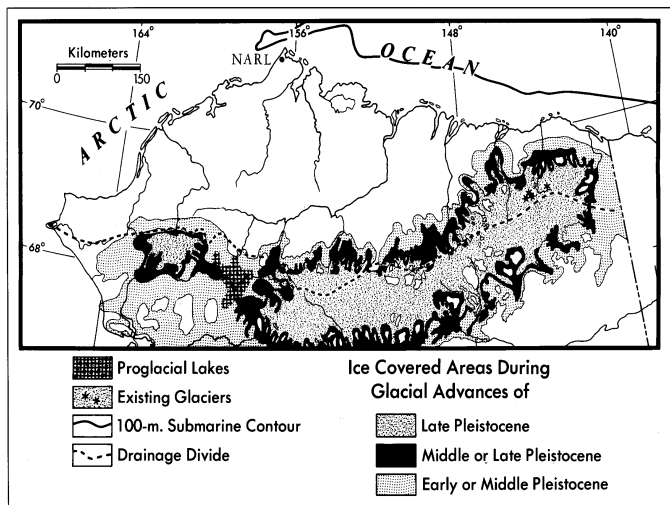


Fig. 4. Pleistocene glaciation in relation to present-day North Slope drainages.

high western bank. Erosion of these bluffs has exposed the Cretaceous strata containing rich fossil beds (Fig. 5) of polar dinosaurs (Nelms, 1989; Gangloff, 1990; 1998). Resuspended Mesozoic and Pleistocene sediments (including Gubik Formation) make up a considerable fraction of the modern river's sediment load as it reaches the delta. This sediment load does not include sediments from any active glaciers in the Brooks Range. The Colville's current delta may post-date the Holocene retreat of permanent ice fields from the river's drainage area.



Fig. 5. Dinosaur excavation site in the 1990s, at base of eroding Mesozoic deposits, west bank of the lower Colville River, a few kilometres upstream of the delta itself. University of Alaska Museum photo, by Ron L. Mancil.

To conclude this introductory overview, the Colville River serves an entirely arctic drainage with no present glacial input, and terminates a geologically young delta. By most global scales of comparison, the Colville is a river of modest dimensions (Table 1). Its delta, although modest compared to other arctic deltas is noteworthy for the dynamism and the insights it provides on the geologic history of the Arctic Slope. In a separate chapter (Walker, this volume) I point out that the delta of the Colville River forms Alaska's largest single intrusion onto the Beaufort Sea shoreline. This interruption breaks the general pattern of low coastal tundra-covered cliffs along the mainland shoreline making up this segment of the coastal zone of Alaska's North Slope Borough. Despite its prominence as a geomorphic feature, the Colville River delta was unappreciated outside northern Alaska until a few decades ago. Indeed, scientists afforded it no more than a few paragraphs in exploratory accounts until the 1960s. Stefansson (1913: 115) mentioned it, and Leffingwell (1915: 92) discussed it briefly.

Table 1. Comparative dimensions of river systems that flow into the Arctic Ocean. The Colville River delta (670 km²) ranks it higher (12th of 15) than would be expected on the basis of its modest basin area (54 000 km²—15th of 15) and the volume of its annual discharge (16 km³—14th of 15). The Colville's annual sediment load of 5 800 000 metric tonnes, however, ranks it 9th of 15, explaining the dynamism and relative geological youth of the Colville River in its modern route to discharging into the Beaufort Sea

River Name	Basin Area 10³ (km²)	Delta Area 10² (km²)	Annual Discharge (km³)	Sediment Load 10⁵ (m-tonnes)
Lena	2424	300	525	210
Mackenzie	1766	130	281	420
Yana	238	66	31	30
Indigirka	362	50	50	139
Yenisei	2590	45	620	130
Kolyma	660	32	132	82
Ob-irtysh	2545	32	429	165
Pechora	324	32	131	135
Yukon	855	30	140	600
Pyasina	182	10	101	34
Dvina	357	9	110	38
Colville	54	6.7	16	58
Olenek	219	5	32	10
Khatanga	364	0	85	14
Anabar	100	0	13	4

A CHRONOLOGY OF RESEARCH HIGHLIGHTS

Beginning in 1961—four years after *Sputnik* was launched, and two years after Alaska achieved Statehood—the Colville River delta became the object of numerous studies. These studies eventually dealt with the varied areas of geomorphology, hydrology, oceanography, biology, archaeology, economics, sociology, engineering and other specialties. The Office of Naval Research (ONR) and NARL deserve credit for partnering with the Coastal Studies Institute (CSI) and Department of Geography and Anthropology, both of the Louisiana State University (LSU), to focus attention on Alaska's largest river system to lie completely north of the Arctic Circle. This chapter emphasizes the broad and pioneering nature of the research on deltaic processes performed by our group from LSU. The technical literature dealing with the Colville River delta is sizable and still growing rapidly some four decades later. It may have been no more than an uncanny coincidence that ONR and LSU teamed up in 1960-61 to embark on deltaic process studies. Yet one insider's chronicle of the early 1960s suggests that a spectrum of interests—petroleum geologists, land managers for the new State of Alaska, and the emerging self-determination movement among Alaska Natives—were expecting commercial petroleum

discoveries to be made nearby (Roderick, 1997:151-172). Roderick's account shows that the basic environmental process studies addressed by the LSU group, beginning some seven years before the Prudhoe Bay oil discovery, were bound to yield results of unusual value to future decision-makers. In retrospect, NARL's support of deltaic research qualifies as one of the significant events in the Laboratory's passage of the half-century mark.

LSU research began a reconnaissance program with two researchers: Morris Morgan and myself. From the outset George and Nannie Woods (Fig. 6) and their sons, Abe and Joeb assisted us in every phase of fieldwork. With equipment and supplies from NARL, the team worked out of a tent pitched at Nigilik also known as the Woods' Camp (Fig. 7). Most of our work was done by boat with Joeb Woods (Fig. 8). The work involved echosounding of strategic river locations, establishing stations for bank erosion measurements, and mapping distinctive deltaic forms. Because 1961 was a "reconnaissance" study, the primary durable result of the first season was probably our choice of the site for a permanent camp that supported research from 1962 on.

Our decision to locate the 1962 camp at Putu, near the head of the delta, led NARL to cat-train two NARL



Fig. 6. George and Nannie Woods at Nigilik in 1962.



Fig. 7. Nannie Woods splitting whitefish for drying at Nigilik camp, 1962.



Fig. 8. Joeb Woods and boat work near the Gubik Formation on Nechelek Channel.

cabins to the site during the Spring of 1962 along with a boat and other necessary equipment. From our base camp at Putu (1.5 km east of the present site of Nuiqsut) the 1962 field season began in March and lasted until September. It involved hydrologists from

Hydroconsult in Uppsala, Sweden in addition to the LSU team.

We arrived at Putu Camp early enough in the 1962 season to examine the river prior to snowmelt and breakup. The team used a SIPRE corer to drill many holes through river ice, and as far downstream as sea ice at the delta front. Current meters detected no flow in the river channels. Conductivity measurements indicated that seawater had migrated upstream to a distance of 64 km (40 miles) from the mouth in the main channel of the Colville. These two late winter observations led us to conclusions about the seasonality of the river that were at once intriguing enough to bear re-stating. First, the Colville's entirely arctic drainage ceases to discharge water by some time during the winter. Second, as a consequence of the shutdown in freshwater flow, denser salt water from the Beaufort Sea inevitably moves by gravity (or figuratively pushes its way upstream by displacing less dense fresh water from beneath) a considerable distance up into the Colville River's deep but inactive channels (Arnborg et al. 1966). Over the years since 1962, the implications of these early conclusions have assumed wider importance. For example, domestic and industrial users of fresh water could not rely on "mining" pools of freshwater in the lower reaches of the Colville. Another example of wider implications is fishery biologists' understanding of how marine water intrusions drive anadromous ciscoes each fall to move upstream to the Colville River's deeper pools at the beginning of 8-9 months of overwintering (Schmidt et al., 1989; Norton and Weller, this volume).

After the late-winter work in 1962, we monitored breakup in detail and constructed a seasonal model for pre-breakup, breakup and post-breakup flooding. In 1962, as in subsequent years, this model covered a period lasting about three weeks (Table 2; Fig. 9). The model incorporated calculated stage variations and discharge volumes. Some of our most important findings from the breakup period were to assess the several distinct but simultaneous roles that floodwater played, in eroding, transporting and depositing sediments. We were confident enough in our demonstration of the connections between ice wedges and the sequence of thermoerosional niche formation and block collapse to present results at the First International Permafrost Conference in 1963 (Walker and Arnborg 1966; Walker, this volume).

Making detailed cross-sectional profiles of the river (Fig. 10) and determining the river's discharge, chemistry, and suspended and bottom load occupied

Table 2. Seasons on the Colville River delta.

SEASON	INITIATED BY	CHARACTERISTICS	APPROXIMATE DURATION
WINTER	Appearance of solid ice cover	Discharge to Ocean Discharge ceases	33 weeks
EARLY LATE			
SPRING	Appearance of melt-water		
PRE-BREAKUP		Snow melt-water accumulates and flows over and under ice	3 weeks
BREAKUP		Removal of river ice	
POST-BREAKUP		Flooding following breakup	
SUMMER	End of breakup flooding	Precipitation-driven fluctuations in level	12 weeks
FALL	Air temperature drops below 0°C	Low air and water temperatures, low, stable river levels	4 weeks

most of the 1962 field season after breakup. During the rest of the 1960s, several field seasons were devoted to expanding on the research begun in 1962, and to monitoring bank erosion. A main objective of these field seasons was to refine our understanding of the relative importance of the various processes that shape the geomorphology of the channels and banks of the delta.

In addition to obtaining more data on bank erosion, the team undertook a study of the sequence of events that takes place when river channels break through the banks that contain deltaic lakes, a process known as “lake tapping.” We systematically evaluated hundreds of lakes of various sizes, distances from active channels, and retrospectively analyzed already tapped lakes of various ages. This work allowed us to piece together a picture of lake tapping along the various distributaries, and to monitor the changes that occurred in lakes themselves once they had been tapped. Throughout all of these seasons, Joeb Woods served as boatman and

helped us refine our understanding of the delta’s dynamic environments. Many lakes were echosounded utilizing NARL’s floatplanes.

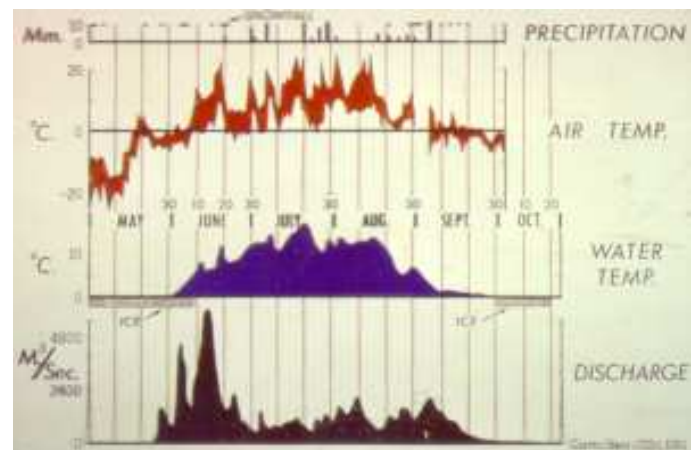


Fig. 9. Short open-water season (19 weeks) of the Colville River, illustrated by annual discharge, water temperatures, air temperatures and precipitation, in relation to seasons of ice cover (approximately 33 of 52 weeks annually).

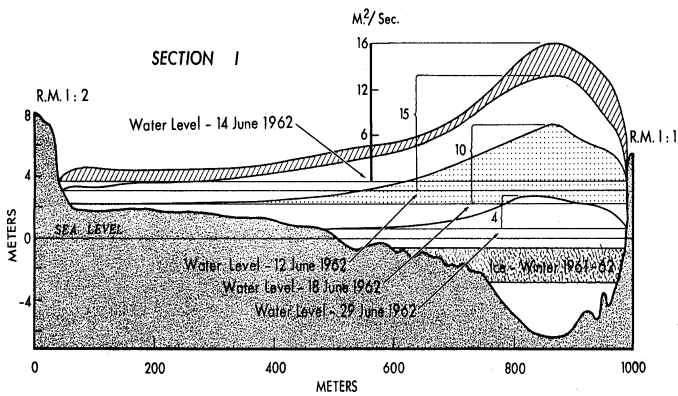


Fig. 10. Late winter, through breakup, 1962: river levels and flow rates at Putu.

We found that after lakes were tapped or breached by river channels, these tapped lakes became significant sediment traps. Sediment-deposition accompanies flooding on the delta. When sediment-laden high water encounters lake basins, it slows, so that the sediment drops out of the water column onto the lake bottoms. Tapped lakes, being connected to the high-velocity channels that tapped them, fluctuate with the channel flow. Upon entering tapped lakes, sediments fall from the water column. Coarser sediments pile up around the entrances to tapped lakes. Tapped lakes thus create their own deltas entering onto river channels (Walker 1978).

The seasons of 1971 and 1973 were especially long and productive. As many as 13 researchers and technicians were involved. The project had expanded enough that NARL cat-trained two more cabins to the Putu site. For the first time, we were provided a generator, which not only made living more comfortable but also allowed use of equipment that needed electricity. Among our assistants were five graduate students who worked on special assignments that led to Master's and Doctoral degrees.

Our main objective during these two seasons was to examine the interaction of river water as it enters the sea. This exercise meant using a helicopter to establish and monitor stations on the sea ice offshore before, during, and after breakup flooding (Fig. 11). More than 50 stations were established, some of them sampled as many as seven times, in order to track the progress of river water over and under the sea ice. Salinity, temperatures, and suspended matter were checked and the information used to determine the discharge of the river. Other research involved examining the micromorphology of gravel and sand bars and mud flats. Sediment cores were taken for analysis in Louisiana.



Fig. 11. Helicopter and sea ice research site, 1973.

During this period the modern community of Nuiqsut was established on the Gubik terrace near the head of Nechelic Channel. After the consolidation of Nuiqsut, we based our research from the community. Most of the research after 1973 has been supported by the North Slope Borough, and related to CIP's dredging program to mine gravel from the Nechelic Channel. Among the able field assistants from the community were Joeb Woods, his son George, Abe Woods, and Norman Lampe.

In the course of the two decades that our research was supported by ONR and NARL more than 100 research articles, abstracts, reports and reviews, and 11 theses and dissertations were produced. In addition, at least 60 presentations about the Colville research were made at national and international conferences. Most of the published papers are available in a three-volume set entitled "The Colville River Delta," a copy of which was donated to the Tuzzy Consortium Library in Barrow. Many of these reports are also available on the World Wide Web, and include color and black-and-white and aerial photographs, at <http://diglib.LSU.EDU/digitalibrary> from which material can be downloaded.

Today, the delta is a very different place from what it was 40 years ago when it was virtually unknown to all but the residents of the North Slope and a few big game hunters. It now has a town with a population of more than 400 people, a long air strip, virtually all the amenities associated with modern living, and oil and gas wells being drilled for commercial production.

The research conducted during the 1960s and 1970s under the sponsorship of ONR, NARL and CSI could not have been accomplished without: 1. The support and encouragement of ONR, NARL and CSI personnel; 2. The pilots, who not only supplied our needs, often during very adverse conditions (Figs. 12, 13), but went far beyond the call of duty to ensure that the research data desired was obtained; and 3. The Woods' family whose knowledge of the delta made the data obtained more meaningful than it otherwise would have been and whose assistance during a few trying times helped make the whole experience more enjoyable and meaningful.

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Fig. 12. R4D delivering equipment and supplies for the Putu camp in 1971. The landing was made on the river ice near where Nuiqsut is now located.



Fig. 13. Lloyd Zimmerman—one of NARL's pilots without whom the research on the Colville could not have been accomplished.

Down Through Time: Editor's Introduction

David W. Norton¹

The title of this introduction was a phrase that ran insistently through my head as I worked to fine-tune authors' contributions commemorating NARL's 50th anniversary for this volume. Anniversaries of any dimension are excuses for constructive reminiscences, but we especially value 50th Anniversaries by calling them "golden." Human biology happens to permit us to live and husband our faculties long enough, so that a span of 50 years falls within the recall of senior members of society. A 75-year span exceeds the endurance of all but a hardy few, whereas a 25-year span is perhaps too short to acquire all the perspectives that mature over entire careers—or 'down through time.'

Writers and editors have nevertheless captured earlier phases of NARL development admirably in several landmark publications. Invitation to edit a book on the shoulders of these earlier works was thus a challenge to update material with which to evaluate NARL's continuing influences on ideas, people, and communities. To me, that challenge meant trying to distill the wide range of NARL's meanings to people of all ages, and to reflect the institution's changing dimensions over its entire history.

I have found it sobering to be reminded by this process how easily we forget earlier generations' experiences, or how hard we must work to remain conscious of the past, especially of the rich past surrounding Barrow and NARL. By adopting a modification of the title of Charles D. Brower's (1942) popular account of his "fifty" years in the Arctic (an account actually spanning 57 of his 61 years, 1883-1945, in the Arctic:), I hope symbolically that this book consciously links NARL's history with that of C. D. Brower's earlier span of experience at Barrow.

Although this has not turned out to be a history book, I repeatedly encouraged authors to speculate on the historical significance of obviously momentous events or moments of discovery, as well as to record seemingly

insignificant recollections. After all, thinking downward or upward through time is no small challenge. Future scholars deserve a representative sample of the flavor of NARL's first half-century, to enable them to second-guess what are today's speculative ideas.

In the 1990s, for illustration, the marquee on the bus plying one of Barrow's three public transit routes identifies NARL as a destination where the bus makes a turnaround before heading back to town. The 'N' in the NARL marquee has clung to the "Camp" or complex, despite the U.S. Navy's withdrawal from Laboratory stewardship a generation ago. The bus-barn lies in the heart of the City of Barrow, a special place indeed, for being at once Iñupiaq and cosmopolitan. Barrow and NARL connote historical meanings far deeper than mere bus destinations. We owe it to ourselves to wonder: could Laurence Irving have imagined in August 1947 that "the village," half a century later, would run a city bus to the Laboratory complex that he founded some 8 kilometres (5 miles) down the beach?

Posing that sort of question heeds T.S. Eliot's (1932:14) advice to writers to be conscious of "not just the pastness of the past, but of its presence."

Barrow's own legacies promptly alloyed with activities by NARL after 1947, to magnify this arctic community further in global awareness than anyone might reasonably have expected—even allowing for Barrow's growth from a few hundred people, to a current count of more than 4000 residents. NARL's first 20 years, 1947-1967, figuratively held a magnifying glass over this northernmost peninsula in Alaska. Ukpeagvik's people, history, culture, environments, whaling traditions—all things about Barrow, in short—were magnified. (During a circuit of scientific and engineering conferences in Britain and Norway in the 1970s, at least 10 different European colleagues asked me about the population sizes of Barrow and Fairbanks. Each was incredulous at learning that such small communities, by European standards, could be so prolific in publication of scientific work.) By the early

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1960s, the cumulative accounts of the Arctic associated with Barrow and NARL had built a reputation in arctic scholarship that captivated many scientists' imaginations. At the time they captivated mine, I was just another college student in the eastern U.S. who had yet to cross the Arctic Circle, but who was already sure that Alaska, Barrow, and NARL were to be my scientific "Mecca." NARL, after all, was the base from which my heroes, Laurence Irving and Frank Pitelka, had enlarged the Arctic's importance in scientific thinking. Evidently, my being deeply affected by the attractions of Barrow and NARL put me in good company. Other contributors (e.g., Feder; Koranda; Burns; LeSchack, this volume) remember with awe and indelible clarity their arrival and first days at Barrow and the Laboratory.

NARL's 25th Anniversary coincided with implementing the Alaska Native Claims Settlement Act (ANCSA) which Congress enacted as a necessary prelude to construction of the Trans-Alaska (oil) Pipeline from Prudhoe Bay to Valdez. The Silver Anniversary year of 1972 was also the fourth year of NARL's being headquartered in its new Laboratory, Building #360 (Fig. 1). A special edition of the journal *Arctic* in 1969 had celebrated the new facility with papers expressing optimism for continuity in many fields of arctic investigations. Likewise, celebration of NARL's 25th Anniversary in 1972 was marked by a symposium and its publication by the Arctic Institute of North America (Britton [ed.] 1973). That symposium reviewed arctic science, in the optimistic style of a "state of the union" address.

There was no hint in the Proceedings of NARL's 25th Anniversary in 1972 that a sharp turn lay ahead in NARL's future. Yet in hindsight, we can see that an end to one phase of NARL's history had become nearly inevitable.

First, discoveries of commercially exploitable arctic oil and gas in the winter of 1967-68 meant that scientific talent and emphasis in the U.S. Arctic were bound to be drawn away from Barrow, eastward on Alaska's North Slope. The arctic 'magnifying glass' was destined to move over the Prudhoe Bay oilfields for a number of years.

Second, NARL's future was scripted by an eastward shift in the U.S. Navy's arctic priorities, where its adversary's submarine forces concentrated in the Atlantic approaches to the Arctic Ocean (Kelley and Brower, this volume).

Third, I suggest that changes in the conduct of research itself had generated some degree of previously unrecognized disenchantment with science and scientists by the public generally, and among the Iñupiat of Alaska's North Slope specifically. Several papers in this commemorative volume manifest nostalgia for the simpler, more adventuresome partnerships between scientists and the community during NARL's first two decades. We can think of that as the dogsled era. During NARL's first 20 years, dog teams disappeared, while research was becoming a more bureaucratized, impersonal, and costly business. Specialists and sub-specialists replaced the generalists and natural historians of the Arctic who founded the Lab. This replacement led, I believe, to younger Iñupiat Eskimos' sense of being disconnected from science as a personally meaningful process. Research that had been both fun and productive in the eyes of an earlier generation, became more obscure to that generation's children and grandchildren. A greater share of activities at NARL represented "Big Science." Researchers coming to NARL increasingly rushed into and out of the field, depended on more sophisticated technological support, and communicated among themselves in specialists' jargon, such as mathematical and computer models.

As an aside on this changing nature of science, it may be instructive to recall that a parallel upheaval shook U.S. health care professions. That upheaval developed earlier (the mid-1960s to the early 1980s) than the most difficult upheaval in NARL's first 50 years (1978-1990). The General Practitioner MD was disappearing by the 1960s ("doctors don't make house calls any more"). As specialists practicing hi-tech medicine in big-city hospitals held sway, whole regions of rural communities lost their 'family doctors' to more glamorous positions offered by urban medical centers. Then, at about the time the U.S. Navy departed Barrow, John McPhee (1986:75-175) was able to describe the return to rural Maine of primary care physicians, who by the late 1970s called themselves "Family Practitioners." Compared to physicians, scientists and scientific research have been slow to recoil from excesses of specialization. While medical "Family Practice" began returning to rural parts of the contiguous United States, the equivalent of general practice in scientific discovery was still vanishing from rural Alaska: Fewer naturalists or natural historians spent unhurried time working in and around Alaska's smaller communities (Sturm, 1999). Upon joining the North Slope Higher Education Center in 1989 at Barrow, I discovered that my students'—and more painfully, my teaching colleagues'—perceptions of science and scientists had

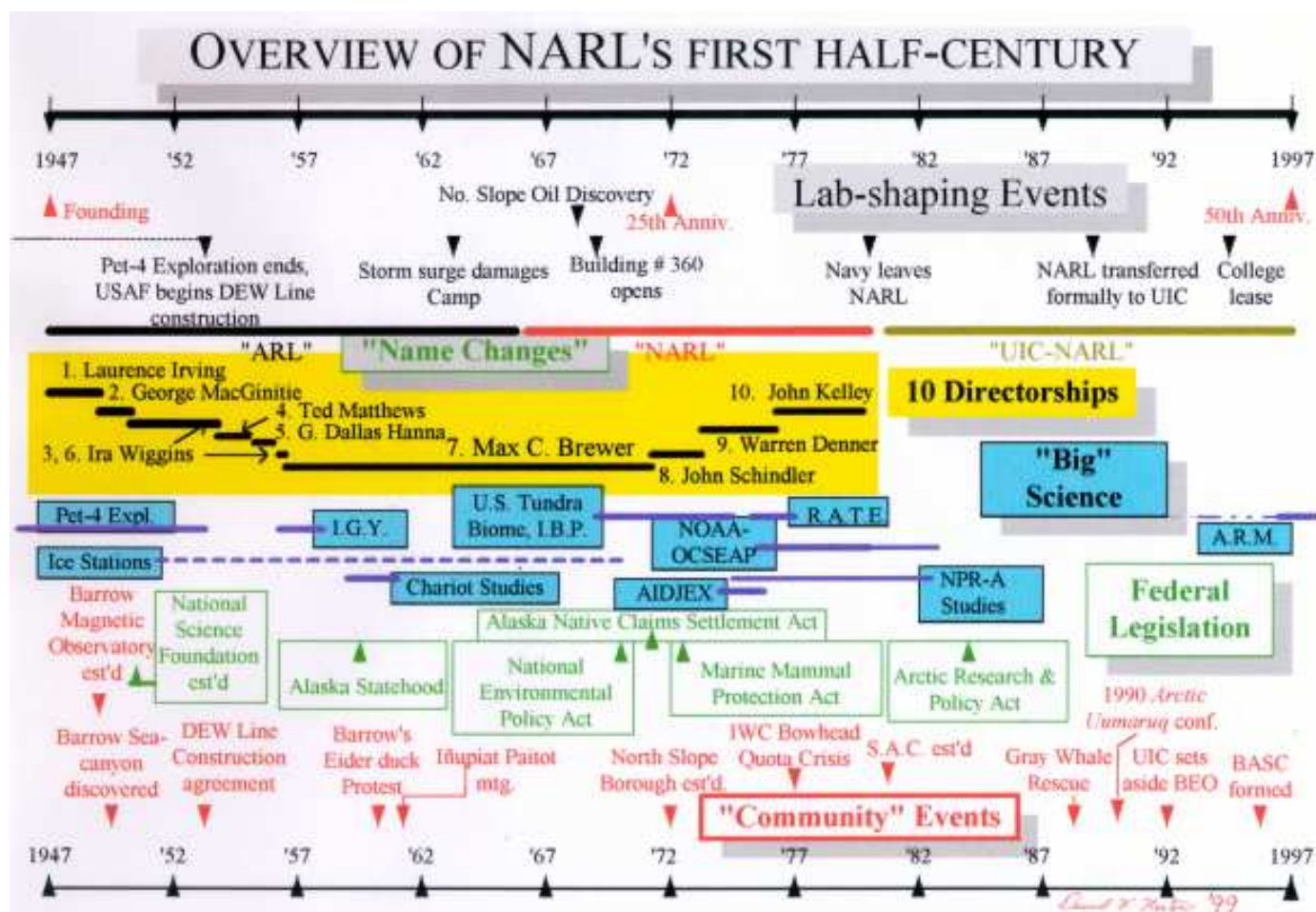


Fig. 1. Compressed summary of milestones in ARL-NARL-UIC-NARL history, 1947-1997.

become alarmingly negative. Negative public perceptions of researchers made it difficult to convey enthusiasm for sciences in a classroom. Even community-dedicated arctic researchers like Dr. Tom Albert (this volume) have had to deal with public perceptions of researchers as being aloof, solitary, self-serving, fiercely competitive with other scientific geniuses, and hopelessly difficult for non-scientists to understand.

Finally, also in the same year that NARL reached its quarter-century mark, Barrow became the seat of home rule government for people of Alaska's North Slope. Much of the workforce for home rule government, the North Slope Borough, was drawn from residents whose youthful work experience had begun at NARL. Staff experience at NARL also fueled the workforces for corporate entities, the Arctic Slope Regional Corporation (ASRC), the Barrow village corporation (Ukpeagvik Iñupiat Corporation, UIC), and the seven other village corporations mandated by ANCSA. If this new governmental and corporate self-determination did not discourage NARL's continuity, it must at least have distracted the community from being concerned for NARL's future.

Given three discouragements and a distraction, we should marvel that positive legacies nevertheless remained rooted in NARL experience, and that NARL itself carried on through the years of the Navy's waning interest and beyond (Albert; Brown; Burns; Dronenburg; Kelley and Brower, this volume). By themselves, the sweeping and irreversible changes at many levels in the State of Alaska triggered by the Pruhoe Bay discoveries (cf. Roderick, 1997) could have toppled a less sturdy institution than NARL. That the Laboratory carried on as an island of continuity in a sea of discontinuities becomes the more remarkable for its contrast to the fates of other institutions.

By the end of that Silver Anniversary year of 1972, the Office of Naval Research had hinted at wanting to get out from under its arctic brainchild. As it turned out, eight more years, especially productive of research, were to pass between the Navy's first detected intentions to leave, and its handing the door keys to local caretakers. The Navy's and University's operation of the Laboratory was given at least two extensions before their final pullout in 1980 (Kelley and Brower, this volume).

After the Navy and University of Alaska did leave Barrow, UIC's Real Estate Department became the unofficial landlord of the NARL facility for nine years. During this period of uncertainty, research continued at UIC-NARL, but its scope was sharply reduced, during what many call NARL's "lean years." UIC-Real Estate's major scientific tenant became the North Slope Borough's Department of Wildlife Management. The Department leased the former Animal Research Facility (ARF) at Building #350, together with a cluster of laboratories in the Science Wing of Building #360, which it still uses as offices for Department biologists and staff. The North Slope Higher Education Center briefly leased other labs for office and teaching space, but abandoned NARL for downtown Barrow by the end of the 1980s. Wildlife Management continued to extend NARL's traditional hospitality to visiting scientists—especially to graduate students—engaged in various research projects.

UIC's quiet stewardship of 'Camp' for 17 years—nearly 40 percent of NARL's first half-century (Fig. 1)—has yet to be fully acknowledged. Even today, some researchers are surprised to learn that investigators have worked effectively from NARL facilities without interruption. Halfway through NARL's leanest dozen years, Congress passed the U.S. Arctic Research and Policy Act (ARPA) in 1984. Although ARPA was intended to expand arctic investigations, the legislation produced few noticeable results at Barrow or NARL for some six years. UIC-NARL's Camp Dining Hall catered to the trickle of scientists using the Laboratory in the 1980s. In that dining hall, scientists mingled with other members of the NARL Camp community, although some of the more interesting scientific mealtimes migrated to the ARF's cook-for-yourself facility in Building #350 (Quakenbush, this volume). Non-scientist tenants of the NARL complex included UIC Construction, Spenard Builders' Supply, Barrow Gasfields Operations and Maintenance, Barrow Technical Services, and Bowhead Transportation. Later, LCMF Architects and Engineers, and the North Slope Borough's Department of Energy Management joined the Camp neighborhood. The NARL Camp continued the diversity that it inherited from the Navy's and University of Alaska's stewardship. Scholarly efforts continued to be enriched by legacies of Barrow in the mid-1980s. That was when Charles D. Brower's daughter, Sadie, participated in publishing her reflections on a 60-year span of arctic experiences (Blackman, 1989). Her account is especially valuable for overlapping with some 25 years in her father's account (Brower 1942) and continuing into the second quarter-century of NARL's operations.

An upswing in scientific activities based in Barrow began with three events in 1990-91. First, Barrow's fledgling community college hired its first faculty member to teach University of Alaska science courses. Our college laboratory for teaching natural sciences took shape adjacent to the Department of Wildlife Management offices in Building #360 at NARL. Second, Barrow's profound concerns for the health of science and science education were expressed in the symposium hosted by the community in March 1990 (Norton [ed.] 1992). Third, National Science Foundation contractors installed instruments to monitor ultraviolet (UV) bands of the spectrum of incoming solar energy at Building #360. This UV sampling complemented the monitoring of stratospheric ozone by NOAA's CMDL station on the "Old Beach Ridge" south of the DEWline station. Of these three events within a 9-month span, only the symposium drew much notice by news media. All three events nevertheless heralded a re-assertion of long-term scientific interest in this segment of the Arctic. Barrow's attraction for arctic researchers once again seemed to be vindicated as an asset to the community, in the manner foreseen by the visionaries who have regularly associated with NARL since 1947.

In the following two years, NSF introduced new long-term ecological research projects at Barrow and Atkasuk (Webber and Hollister, this volume) and the U.S. Department of Energy began to undertake with community partnership a 10-year intensive project known as Atmospheric Radiation Monitoring (ARM—Zak et al., this volume). In 1992, UIC took further initiative to encourage long-term research into phenomena such as Global Change, by setting aside the 7500-acre reserve known as the Barrow Environmental Observatory (BEO). Land designated for the BEO adjoins the NOAA-CMDL site, extends southward nearly to the Gaswell Road, eastward to the shore of Elson Lagoon, and encompasses the "Old Beach Ridge," Central Marsh, and East and West Twin Lakes (Brown, this volume).

The most visible of events at the NARL Camp in the mid-1990s was UIC-NARL's taking on a new tenant. The Borough's North Slope Higher Education Center had been renamed "Arctic Sivunmun Ilisagvik College" in 1991, and subsequently privatized when, in 1994, the North Slope Borough contracted its management as a vocational training center to a subsidiary of UIC, Pignik Management Corporation (PMC). In 1994-95, PMC set out to consolidate what it called the Mayor's Workforce Development Program (WDP) to a physical facility that could serve as a residential campus (Fig. 1). It was to become the "NARL Campus." This re-

direction of community emphases in post-secondary education was patterned on U.S. Department of Labor's Job Corps programs elsewhere. PMC leased Building #360 from UIC-Real Estate (except its Science Wing) and a number of the separate large Quonset huts in the NARL Camp. WDP took over running the Camp Dining Hall from UIC, and the UIC-NARL Hotel was displaced from the Personnel Wing of Building #360 to mobile housing units behind the Lab, leaving the Personnel Wing to be used as a student dormitory. All remaining space in Building #360 was converted to offices for WDP managers. Teaching shops were built as part of ambitious upgrades to four large Quonset huts and to the NARL gymnasium building. A new gymnasium was created out of the former shop and window fabrication plant between Building #360 and the ARF (Building #350).

The NARL Camp for a while resembled an urban renewal project. Refurbishment of NARL buildings was carried out in the expectation that under-employed North Slope adults could be attracted by opportunities to become certifiably skilled welders, waste treatment plant operators, electricians, carpenters, commercial drivers, and heavy equipment operators. The local college's academic courses, including sciences, stayed in place, but were overshadowed by the magnitude of resources allocated to training for job skills.

Privatized management of the community college lasted 18 months, an interval in which the physical plant upgrades were largely completed. In mid-1996, the college again reorganized, to become an independently governed public educational institution. The vocational school's managers let the name "Workforce Development Program" lapse, but retained extensive leases on real estate at the NARL Camp. Re-namings continued: Arctic Sivunmun Ilisagvik College became Ilisagvik, then Ilisagvik College.

Meanwhile, with less fanfare, NARL's positive legacies had led gradually to the formation of a critical mass of scientists and technicians residing in Barrow by the early 1990s. This critical mass included the nucleus of biologists with the Department of Wildlife Management, veterinarians with the Borough's Health Department, NOAA's CMDL scientists, the college's science faculty, and the growing staff of the U.S. Department of Energy's ARM project. Because the function of hosting visiting scientists and providing their logistics needs promised to outstrip the Wildlife Department's capacity, UIC and the resident scientists at the NARL 'Camp' founded the non-profit membership organization in 1994 (Fig. 1), to be known as the Barrow

Arctic Science Consortium (BASC). This consortium's objectives were to manage the BEO, and to attract and support both visiting and resident researchers, whose investigations once again included an expanding range of disciplines. Consistent with its mission of "bringing community and science together," BASC naturally inherited the challenge of organizing celebrations of NARL's 50th Anniversary, a task which immediately absorbed BASC's founding Executive Director, Dr. Glenn Sheehan, beginning in 1996.

Personal observations on which I base interpretations of the latter 30 years of NARL's first half-century of transitions began during the Laboratory's "heyday." In 1968, a few months after the announcement of Prudhoe Bay oil discoveries, I arrived to begin the first of five field seasons of graduate physiological research here (Norton, Letters Section, this volume). After graduating in 1973, I returned to NARL a dozen times for the Outer Continental Shelf Environmental Program (OCSEAP—Norton and Weller, this volume). The most significant scientific event of the era, 1975-82, was undoubtedly OCSEAP's first Beaufort Sea Synthesis Meeting, conducted by Gunter Weller at NARL in February 1977 (Weller et al., 1977; Barnes et al., 1984; Weeks, this volume; Burns, this volume). I happened also to be on hand in October 1988 as a member of the North Slope Borough's Science Advisory Committee. Committee members took time off from deliberating at NARL, to go out on the ice in final days of the media-celebrated "rescue" of gray whales trapped in sea ice.

My longest, most privileged association with Barrow and NARL began at the end of 1989, when I moved here to serve as the local college's first natural sciences instructor. During the ensuing decade, my ambition was to become a scientific 'general practitioner' for students on the North Slope and elsewhere in Alaska. That is, I became committed to replacing negative images of science and scientists, by responding to community appetites for science (analogous to its needs for 'family doctors') to reawaken a broad trans-disciplinary appreciation for the enduring legacies of arctic science. From my narrowly trained specialization in vertebrate physiology, this commitment meant branching out into many subjects: earth sciences, history of science, paleontology, climate and sea ice studies, museum studies, even into some social sciences.

Groping toward holistic understanding, as I now appreciate it, was a splendid assignment, encouraged in my case by the unique educational philosophy behind the best of North America's community colleges. This endeavor deepened my respect for pathfinding

generalists and visionaries in arctic research, typified by Laurence Irving, Pete Scholander, Don Foote, Max Britton, Bob Rausch, Bob Elsner, Frank Pitelka, and John Burns. Besides any value in scholarly circles, this commitment especially allowed me to appreciate the comprehensive and holistic observational skills that Iñupiat colleagues traditionally call upon in surviving when on the sea ice, and traveling arctic rivers, lakes, and tundra. The local heroes identified repeatedly in the pages of this book include Simon Paneak, Kenneth Toovak, Sr., Harry Brower, Sr., Chester Lampe, Frankie Akpik, Arnold Brower, Sr., Pete Sovalik, Nannie and George Woods, Percy Nusunginya, and many others.

These perspectives helped persuade me that NARL's character had to be grasped by exploring the Lab's resiliency in lean times. NARL as a name for a bus destination, and as a permanent icon, will persist. Barrow's college, by one or another name or mission, has not shaken the "NARL Campus" designation. The Laboratory has coped with several life-threatening upheavals. Termination of the Pet-4 Exploration Program in 1953, and the October storm surge of 1963 punctuated NARL's early voyage 'down through time,' but the Lab rebounded from its most serious adversity late in its second quarter-century. For carrying the burden of seeing NARL through its most severe regime shift, and assuring NARL's continuity into the new millennium, the North Slope Borough's Department of Wildlife Management and the UIC Real Estate Department deserve overdue recognition. To enable this volume to include accounts of how NARL survived its 'lean years,' it had to await several key contributions from those few authors who could address those years. Delayed publication (for which I accept responsibility) permitted Tom Albert, John Burns, and Lori Quakenbush, for example, thoughtfully to explore the context of some of UIC-NARL's previously unknown and unappreciated episodes and intrigues.

The National Science Foundation's "Barrow Area Research Support Workshop" preëempted several proposed contributions by authors who otherwise would gladly have explored the Lab's future in the pages that follow. Readers interested in the configuration of future research support at UIC-NARL are referred to the proceedings of that workshop, published by the Arctic Research Consortium of the United States (1999). A number of contributors throughout this volume nevertheless articulate scientific justifications for future research based at or near Barrow (e.g., Feder; Alexander;

Reanier and Sheehan; Weeks; Walker; Brown; Weingartner and George; Webber and Hollister; this volume).

Whatever further institutional changes it faces in its next half-century, I am hopeful that the resiliency illustrated here portends UIC-NARL's continuity well into the new millennium.

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Overleaf: Frontispiece. Pete Sovalik, (foreground) obviously enjoying the moment, having snared an arctic fox near Walaqpaa for use in physiological studies by Larry Underwood (background in red watch cap). Photo, R. E. Henshaw, courtesy of Larry Underwood.



Introduction to Alaska's Original Naturalists

Max C. Brewer¹ and John F. Schindler²

The first recorded encounter of the European culture with the Arctic is traced to 325 BC when the Greek, "Pytheas of Maseia" sailed north and found a strange substance he termed neither land, nor air, nor water (Asimov 1975:42). This was Mediterranean man's first encounter with sea ice. At that time, the Iñupiat, or their forebears had been coping with sea ice for some 8000 years. That means that the northern Native peoples have at least 10 000 years experience in observing the passage of the seasons and other natural events.

It is not necessary to have passed formally through the halls of a university to become a natural scientist. The keen and patient observer of nature, who can long remember what he has seen, and can relate it to other naturally occurring processes and events, qualifies as a naturalist. The very existence of the Iñupiat was often dependent on keen observations and memory. Thus, their survival in this harsh environment made them great naturalists. The passing of people like Simon Paneak, Pete Sovalik, Harry Brower, Sr., and Al Hopson, Sr. reminds us that we are slowly losing Alaska's original great naturalists. Some of their vast knowledge is now part of the written record, but unfortunately a great deal has been lost, and more is being lost every day. The celebration of NARL's 50th Anniversary and this commemorative volume at least recognize the enormous tribute owed to these naturalists who shared so much.

SIMON PANEAK

Simon Paneak was one of those naturalists who shared his knowledge with many researchers. In some cases he is also listed as a co-author in the scientific publications that resulted. It was to Simon Paneak's family that a Director of the Laboratory entrusted a young undergraduate student in anthropology from Yale for a period of 15 months. The young man learned the language of the Nunamiut and wrote a book of his experiences, what he had learned from Simon, and

what he had learned from other people. The young student graduated from Yale with very high honors in Anthropology and went on to become a Rhodes Scholar and later, a well respected voice in his profession.

PETE SOVALIK, SR.

Pete Sovalik (Henshaw and Brewer, this volume) was another of the Native naturalists, as knowledgeable of the coastal environment as his cousin, Simon, was of the northern Brooks Range and foothills. Pete was mentioned in a book by one of the early explorers who did field work along the Arctic coast in 1913. In over a quarter century of working with the scientists at the NARL, Pete imparted much of his knowledge to them about birds, animals, ocean ice, and ocean currents in Arctic Alaska. He knew the animals and their habits so well that at one time he captured a live lynx with only a piece of fish net. On other occasions, he captured rabid foxes alive, for observation, without the use of either a trap or gun. Pete's formal education was short and interrupted too many times by the need to be on the trail in pursuit of a livelihood. Pete's lack of formal schooling did not prevent him from correcting and improving maps published by government agencies. With his excellent memory Pete could often spot discrepancies. Many workers would ask him to "edit" their drafts. In effect, Pete trained a whole generation of young scientists in how to observe and interpret nature, and how to survive in the Arctic. Well-versed in anatomy, Pete once came into a small settlement where the people were grieving for a young boy who had been mauled, and most of his scalp torn off, by a polar bear. Finding the boy still alive, Pete proceeded to sew the bits of scalp and hair back in place, using coarse twine and a sack-sewing needle. Some 50 years later, this boy still had a full head of hair and no visible scars on his face.

HARRY BROWER, SR.

For the first half of this century, most of the arctic bird specimens, collections of birds' eggs, and mammal study skins found in scientific museums in the contiguous states were prepared by four of the Brower brothers at

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Barrow. Their father, the early whaler Charles D. Brower, saw to it that they were trained to prepare these specimens (Bailey 1948:40; 1971:114). They were widely traveled, including to the northern parts of Banks Island in the Canadian Archipelago, and they spent much of their time in the field observing wildlife in natural poses and activities and used this knowledge later to prepare realistic specimens. In those days, if a scientist wanted to research long-term animal cycles on the North Slope, or the earlier snow geese populations in northern Alaska or on Banks Island, he consulted with Tom Brower, Sr.; if interested in fish populations and ranges, he consulted with Arnold Brower, Sr.; if he sought to develop realistic dioramas for displaying bird and animal specimens, he consulted Harry Brower, Sr.

This ability and artistry with specimen preparation took an unusual turn for Harry some years back. As a joke, and as a parting souvenir for friends, Harry began making single lemming skins into miniature rugs, mimicking a polar bear rug at reduced scale. Harry was suddenly inundated with requests from friends, who “just had to have a lemming-skin rug”. Harry ended up working many hours, often far into the night to accommodate them. Several found their way to executive desks in Washington D.C. The crowning blow, however, came from Mexico; a souvenir shop sent him an order for 5000 lemming-skin rugs. Harry gave up that business in a hurry.

AL HOPSON, SR.

People born and raised without a written language perpetuate their culture through story telling, ceremonial dances, close attention to detail and long memories. Few were better trained in this regard than Al Hopson, Sr. His memories and his capacity for recounting

stories were phenomenal. Included in his recollections was the first arrival at Barrow of the explorer Vilhjalmur Stefansson in 1906. Because Stefansson spent considerable time that first winter obtaining cranial measurements, he was nicknamed “Head Measurer” in Iñupiaq, a name that he never shook in northern Alaska.

Mr. Hopson took the first census in Arctic Alaska in 1930 traveling over 3000 km (1800 miles) by dog team. From that base and later observations, Al could relate from memory the socioeconomic history of the Iñupiat in this century. His descriptions were in great detail, including statistics, which now can be obtained only by synthesizing from a large number of books written by the early explorers, from fragmentary government documents, and from more recent university studies of the socio-economics of the people of the north.

Scientific studies in the Arctic often have been carried out on the shoulders of the people who have learned over the centuries how to live and work here. The people mentioned herein are only a few of those who could have been cited. There are still many among us today and it behooves us to make every effort to see that this valuable resource is made a part of the written record, so that it is not lost to those who follow.

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Peter Sovalik, An Original Arctic Naturalist

Robert E. Henshaw¹ and Max C. Brewer²

ABSTRACT: Mr. Sovalik was an acknowledged expert on sea ice and its movements, possessed an uncanny knowledge of arctic animals and their behavior, and recalled details of North Slope landscapes with near photographic accuracy. Pete excelled at hunting, natural history, storytelling, dancing, and drumming. His contributions to the history of NARL are described from the perspective of an investigator and of a Director of NARL.

Key Words: Animal Research Facility (ARF), animal management, geographic knowledge, story-telling, dancing

No celebration or account of the Naval Arctic Research Laboratory (NARL) could be complete without acknowledging the scientific accomplishments and survival skills of Peter Sovalik. These he willingly shared with visiting scientists through advice and example, and happily through stories, while he managed the Animal Research Facility. Pete's life, experiences, skills, and wisdom provide material for legends. Pete bridged two eras and two cultures. As a child he had lived in a nomadic self-sustaining hunting family, obtaining only five weeks of formal education each year during visits to Barrow. He and his family met and spent time with the explorers Vilhjalmur Stefansson and Diamond Jenness, and he knew Roald Amundsen. As an adult, he and his wife, Isa (Fig. 1), settled in Barrow and raised nine children. When he was young, hunting and survival skills commanded respect in the community; those same skills were essential to NARL.

The second author (MCB) of this tribute often sent Pete as a guide and protector when visiting scientists wanted to work in remote locations or on unstable sea ice. The first author (REH) returned to NARL year after year in part because there was no better way to learn the natural history of arctic animals than to sit for hours listening to Pete. Watching Pete thaw padlocks at -25° F with his bare hands inspired research into blood flow in the feet of large mammals (Henshaw, this volume).

MAPS

When oil was discovered at Prudhoe Bay the U.S. Department of Interior prepared a Draft Environmental Impact Statement on the proposed Trans-Alaska Pipeline System. Pete agreed to collaborate with the first author in presenting testimony about the likely



Fig. 1. Isa and Pete Sovalik at NARL in the late 1960s

impacts of the pipeline on arctic mammals. Pete responded to a series of questions. His answers were transcribed and submitted verbatim. In the course of describing caribou calving on ridge tops Pete sketched a map of northern Alaska. He drew it from the perspective of Inupiat observers, in which Point Barrow appears at the bottom, nearest to the viewer. When we inverted Pete's map and laid it over a USGS map, it was so accurately proportioned that it could have passed for a tracing. We added labels of geographic features, and sent this map in the same orientation he had drawn it (north at the bottom and south at the top) to the Department of Interior. Although the 50th anniversary meeting in Barrow would have been a splendid occasion to display Pete's extraordinary map, neither the Interior Department's nor National Archives' searches were able to locate it.

In the early 1960s, Dr. H. J. Walker asked Pete to provide the Eskimo names of locations in the Colville Delta where Walker was conducting geomorphic and river flow studies. In reviewing the USGS map, Pete pointed to a blank place on the USGS map and exclaimed

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“There is an island here” and sketched it onto the map. No amount of explanation about cartographic methods and aerial photography changed Pete’s mind. A few days later when Dr. Walker checked his survey notes and maps, he found that indeed there was an island—exactly where Pete had said it was. Curious, Dr. Walker asked Pete when he had last been to this island. His answer: 27 years earlier.

MANAGING ANIMALS

Pete empathized with the animals under his care at the Animal Research Facility. He disagreed with scientists’ reliance on CO₂-propelled anesthetic darts to subdue the large mammals, knowing that the darts cause a painful bruise. Thus when Snowflake, the 1500-pound polar bear that Pete had captured as a cub, wedged open her cage door and escaped, Pete resolutely said, “No gun,” as I (REH) readied the dart pistol. Within minutes Iñupiat staff had encircled the compound with vehicles. With no apparent exit, Snowflake started to reenter her cage. Just as the great bear started back into the bear building, someone tried to hurry the bear from behind, wielding a large board. Snowflake turned and ran for the nearest person, Norman Lampe, and sank her teeth into the same part of Norman as had been hit with the board. At this point Pete, alone and armed with only a shovel, calmly began to coax and cajole the bear to return to her cage. As the bear swung her head back and forth searching for an escape route, Pete positioned himself about six feet to Snowflake’s left. Each time the great head swung toward Pete, he stood his ground and Snowflake moved a little away from him. Each time the bear’s head swung to the other side, Pete stepped forward slightly. Watching Pete’s every move, I grabbed a shovel and moved to the bear’s other side. Very slowly and uncertainly, with her head swinging in arcs toward Pete, then toward me, Snowflake reentered her cage in the bear building. Pete, who had faced polar bears in the wild many times, remained calm. The same could not be said of this *Taniq* from New York! Norman Lampe, who ate his meals from a standing position for a couple of weeks, was awarded workman’s compensation.

One winter, rabies hit the wild arctic fox population heavily. Foxes, evidently rabid, chased dogs and even people. Pete learned that the Director wished to know how long foxes could live once infected. He went out (offering himself as bait) and when a fox made a run at him, he calmly gave it a “rabbit punch,” stunning it with his hand. The fox woke up in a cage where it died of the disease 36 hours later.

On another occasion Pete spotted a lynx on his way to work. When Pete asked the Director if the lynx should be captured, the Director replied “yes,” and suggested using a CO₂ dart. Pete refused, saying the lynx could not run far, and that he would just chase it in a tracked vehicle and then just pick it up. Within a half hour Pete returned with the lynx in a net. The lynx never forgave Pete, and spat at him every time Pete fed it.

STORY TELLING

Pete was renowned for his skill in telling both age-old traditional tales and describing events he had experienced. When he was eight years old, Pete joined his uncle on a hunting trip to the east. One day a white man stumbled into their camp nearly dead from starvation and exposure. Vilhjalmur Stefansson, the famous arctic explorer and ethnographer, had eaten his last sled dog many days earlier, while exploring on the offshore ice. After several days, with his strength returning, Stefansson began to ply Pete’s uncle with questions. All questions were willingly answered except one about songs used to bring success in hunting. Pete’s uncle, very embarrassed, protested that he could not divulge the sacred song lest it lose its power. As Pete described Stefansson angrily demanding the song and even storming out of the tent for a day, we could easily picture the irascible nature of the explorer. Finally Pete’s uncle relented and taught Stefansson one short song. Only after the explorer resumed his journey eastward did Pete’s uncle admit that he had taught the great ethnographer a children’s string game song.

Pete told the story about saving ammunition by waiting until two caribou were aligned so they could be killed with one bullet. He told how to keep a polar bear from eating you—“take off all your clothes.” (He said he knew the old lady who did it and survived.) There was the story about the first time an airplane (they thought it was a great silver bird) landed in Barrow. He told how the elder in the guise of a caribou taught the value of industriousness to the lazy man. During the early 1960s Pete told his stories for Barrow children on the local radio station. A decade later as the featured speaker at a NARL seminar, Pete told the stories to dozens of scientists and their families and showed string games, while Isa displayed her spectacular fur parka (Fig. 2). Pete ended every story with a laugh and “That the story. That how my daddy told me.”

BETWEEN TWO WORLDS

Pete’s life outside ARL was equally legendary. His wife, Isa, who understood English quite well but spoke



Fig. 2. Pete and Isa Sovalik dancing at Naluqataq, spring 1966.

English very little, sewed animal skins as skillfully as Pete hunted to acquire them. Pete and Isa produced nine strong and intelligent children, who unfortunately grew up during the dark days when school teachers working for the Bureau of Indian Affairs discouraged respect for traditional skills and wisdom, and forbade children to speak Iñupiat. Life was very difficult for this generation, caught between loving and wanting to respect their parents who so epitomized traditional skills and knowledge, and a world that seemed no longer to value such wisdom. We can imagine how pleased Pete would be, to learn that traditional wisdom is again venerated today.

The legacies of Pete and Isa at the laboratory, among NARL staff, in the village, and in the memories of the visiting scientists, are an important part of what NARL's 50th anniversary celebrates. Everything Pete undertook—hunting (frontispiece to this section), managing the Animal Research Facility, dancing (Fig. 3), storytelling, advising the Director (Fig. 4)—was a class act, a first-class act.

As Pete would say with a laugh, “That the story. That how we did it.”



Fig. 3. Isa and Pete Sovalik dancing indoors, 1971.



Fig. 4. Pete Sovalik, Norbert Untersteiner, and Max Brewer in consultations, late winter 1957. Photo, N. R. Farbman, Life Magazine, courtesy John F. Schindler.

Historical Perspectives on Iñupiat Contributions to Arctic Science at NARL

Karen N. Brewster¹

ABSTRACT: Arctic science is indebted to Iñupiat contributions and contributors through the Naval Arctic Research Laboratory. Notable and pioneering examples of collaborative partnerships between western scientists and Iñupiat who shared traditional knowledge are cited, spanning the years between the Laboratory's founding in 1947 and the Navy's departure in 1980.

Key Words: traditional knowledge, Naval Petroleum Reserve No. 4 (PET4), survival, scientific careers, acknowledgment, employment, legacies

INTRODUCTION

The Naval Arctic Research Laboratory (NARL) developed world renown for its contributions to scientific understanding of the Arctic. The roles played by Iñupiat (North Alaskan Eskimo) in this scientific institution's history, however, are rarely mentioned. Local residents' knowledge of the arctic environment contributed both to the facility's general operations and to the success of individual scientists. Without Native assistance much of the work by NARL's thousands of users and staff over the years could not have been accomplished. These men and women deserve recognition, which in some cases is long overdue.

Before one can address the role of Natives in science at Barrow, and before one can redress overdue recognition, it is important to understand historical stages in maturing partnerships between administration of the Laboratory and members of Alaska's North Slope Native community. Key stages and key partnerships made their contributions possible on an expanding scale over time. Stages and ingredients include the Navy's oil exploration program, their interest in scientific research, and the establishment of the Laboratory itself.

At first, when the Navy developed Barrow as its base of operations in 1944 for oil exploration in the Naval Petroleum Reserve No. 4 (PET4) it was not easy for Natives to get jobs. The Navy hesitated to hire local residents because of the prevalence of tuberculosis and the perception that they were undependable

workers. Only after establishing a health care program, providing TB testing, and helping to improve living conditions in the village did the Navy change its policies to provide more opportunities for Native employment. Iñupiat men were hired as laborers, equipment operators, mechanics, carpenters, and as guides and assistants on survey, seismic and mapping crews. Native knowledge of the country and its extreme conditions gradually came to be recognized as beneficial to PET4 operations.

TRANSITION TO LABORATORY

The Navy's employment of Iñupiat during the PET4 program set the precedent for the Laboratory's Native hiring. The Iñupiat had developed job experience, were accustomed to working in a military setting and knew the procedures of operating the Navy camp. It was a natural transition to shift these workers to activities that supported the Lab's scientific work. In many cases, the tasks and jobs were indistinguishable. They worked at the Lab as workmen, carpenters, machine operators, mechanics, guides, boatmen, dog drivers, trappers, housekeepers, cooks, and office support. Approximately 300 Iñupiat worked at NARL over the course of its 33 years of operation by the Navy (M. C. Brewer, pers. comm., 1997).

The Iñupiat knew their home region and how to survive in it better than anyone else, and many were expert scientific observers in specialized subjects (e.g., Brewer and Schindler, this volume). It quickly became apparent that these specialized talents and knowledge could contribute even more to the Lab's success, so their involvement with scientific projects was increased.

¹ Oral History Program, Elmer E. Rasmuson Library, University of Alaska Fairbanks, Fairbanks AK 99775-6808

Many scientists owe their survival, the success of specific projects, and even their ultimate career success to their Iñupiat guides, who shared what they knew about the Arctic (MacLean, 1992: 37; Feder, this volume). Of the more than 1500 scientists and technicians who passed through NARL from 1947 to 1980 (M. C. Brewer, pers. comm. 1997), only a few recognized fully the contributions of their Native teachers and co-researchers. During this period, scientists were not held to a standard for acknowledging local assistance. Some researchers failed to mention their Native assistants at all, prior to 1980. Others gave thanks or credit in their final reports and scientific publications, although this often inadequately reflected the amount of work and assistance that Natives actually provided. Still other investigators went further in recognizing the knowledge and contributions of their Native collaborators, publicly praised them for their accomplishments, and included them as co-authors on publications.

SPECIFIC PARTNERSHIPS

Examples of the most obvious and successful collaborations are those between Dr. Laurence Irving and Simon Paneak; among Dr. Max Brewer and Pete Sovalik, Kenneth Toovak, Sr. and Harry Brower, Sr.; and between Dr. Tom Albert and Harry Brower, Sr.

Irving and Paneak worked together for twenty years studying the natural history and physiology of animals of the Brooks Range and farther north. Dr. Irving respected and admired Simon Paneak, and infallibly recognized orally and in writing both Simon's contributions and his friendship.

"Simon was my very good and dear friend. I owe him much for all that he told and showed me about northern life...Many people whom I see recall their pleasure and interest in his company, for he was friend, host, guide and teacher of many scientists" (Irving, 1976).

Simon Paneak also benefited from the collaboration: besides earning wages, he enjoyed the work, sharing what he knew, helping science, and reciprocated Irving's friendship.

Brewer worked with Sovalik, Toovak and Brower for fifteen years while he was Director of NARL. He came to appreciate their outstanding talents for creativity and mechanical ingenuity and their extensive knowledge of arctic animals and environments. Pete Sovalik worked as the Animal Caretaker at NARL for 20 years. Kenneth Toovak operated heavy equipment,

was a project support foreman, and assisted many research projects on the sea ice. Harry Brower, Sr. worked for the Navy for 25 years as a carpenter, taxidermist, and on research expeditions. In different forums over the years, all three men have commented on how much they enjoyed their experiences working with scientists and how much it influenced their lives. A decade after retiring from NARL employment, for example, Kenneth Toovak, Sr. evaluated his career of collaboration with scientists:

"I was scared of White people...I stayed to myself. Pretty soon, those folks started coming around to talk to me, asking questions. I started to get to know these people I had been scared of. We started to share the different things we know. This sharing became a very important part of my life. It wasn't easy...But, we kept on sharing knowledge...Scientists wanted my help...they felt good when I helped them on the ice. So I made myself available to them, and we went on sharing" (Toovak 1992: 19).

For more than fifteen years, Dr. Tom Albert and Harry Brower, Sr. worked closely together on the biology of bowhead whales. Tom Albert is always careful to acknowledge Harry Brower's knowledge (Albert, 1992: 25; 1995; this volume), how it guided and continues to benefit the North Slope Borough's whale research program, and the valuable contributions he made to science and to the Iñupiat effort to protect their subsistence whaling activity.

"Harry was a very, very smart man, who was very modest also. He had a tremendous amount of knowledge about the animals and the environment in his area, and he was able to explain it to somebody in a very clear way. He was very patient about answering questions: he wanted you to learn, and he was always available to help. If he were in the Western society...he'd be a great scientist...I can count the number of good teachers I've ever had on one hand. It would take many hands to count the number of less-than-good teachers. But, Harry's one of the best teachers I've had" (Albert, 1995: Tape 1, Side A).

Harry Brower always spoke proudly of his involvement with science, and how he persuaded other whaling captains that it was in their own best interests to cooperate with scientific work on the bowhead whale.

OUTCOMES OF COLLABORATION

At first glance, the benefits NARL offered the people of Barrow are obvious. NARL provided steady employment at good wages. Iñupiat employees at the Laboratory got to travel, meet new and interesting people, perform work they had not done before, and to participate actively in rewarding scientific research. In addition, Barrow's standard of living was improved and the lives of its residents altered forever because of the influx of money, supplies, building materials, outside goods, air service, and contacts with outsiders associated with the Navy and NARL.

Among less obvious legacies of NARL are the positive relationships developed between Iñupiat and scientists. Not only were individual lives changed by what they did and who they worked with, but the Iñupiat community as a whole was influenced by what happened at NARL. Many of today's Iñupiat political leaders worked at NARL. The result has been a community-wide interest in and appreciation for science. The North Slope Borough has become a leader in the effort to involve local people in the design and conduct of scientific studies, recognizing that this collaboration allows them to influence and learn from projects, and to show that local people have meaningful knowledge to contribute (Albert, 1988).

NARL also had a special influence on scientists. They were exposed simultaneously to a new climate and a different culture, both of which required shifts in their perspectives and methods. The scientists also learned from each other. NARL was unusual because it encouraged scientists from diverse disciplines to interact and exchange ideas. At their home institutions, scientists were often isolated by disciplinary specialization and busy teaching schedules (Schindler, 1973).

“One person stated that his time at the ARL had been his single outstanding educational experience. He valued particularly his contacts with other investigators and said he received a dinner-table education at the ARL which could be described as a university in a Quonset hut” (Reed and Ronhovde, 1971: 651).

The employment of Iñupiat at NARL and their assistance to its scientific projects show that incorporating traditional knowledge into scientific work is not new. This incorporation took place at NARL long before it became fashionable amongst northern scientists, and before anyone had ever heard the phrase Traditional Ecological Knowledge or its

more commonly used acronym, TEK. The collaborations discussed here exemplify the successful joining of Native knowledge and scientific approaches in trying to understand the natural world. These relationships grew from mutual respect and made important contributions to the scientific and Iñupiat communities. They show the breadth and wisdom of Native environmental knowledge and demonstrate how essential Native involvement is to scientific inquiry.

Editor's note: The Arctic Institute of North America solicited and published a greatly expanded version of this author's contribution soon after the 50th Anniversary symposium at Barrow. See Brewster (1997) in references, below.

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II. Before North Slope Oilfields: The Laboratory's Formative Years

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Overleaf: frontispiece. ARL personnel posing outside the old main Laboratory (Building #250) on a warm summer day. The date of this photo, by John J. Koranda, is uncertain, but it may have been taken in 1955, while G. Dallas Hanna was serving as Director of the ARL.



Naval Petroleum Reserve No. 4 and the beginnings of the Arctic Research Laboratory (ARL)

John F. Schindler¹

ABSTRACT: A brief historical background sketch is given of the Naval Petroleum Reserve No. 4 and its relationship to the Arctic Research Laboratory. Chronological accounts of seasons through 1953 and the shutdown of the oil exploration program provide historical perspectives on the influences of those times, and on the activities of the participating scientists.

Key Words: Arctic Research Laboratory, ARL, Naval Petroleum Reserve No. 4, Pet 4, Office of Naval Research, ONR

Naval Petroleum Reserve No. 4 (“Pet 4”) was designated by Executive Order No. 3797-A signed by President Harding in February 1923. The lands were withdrawn as a future source of oil for the Navy because of the shortages encountered during World War I. Comprising an area larger than the state of Indiana (96 000 km², or over 37 000 square miles), Pet 4 was set aside (Fig. 1) because of the large oil seeps at Cape Simpson and reports of seeps at Fish Creek and other areas. These seeps were “discovered” by Alexander Malcon Smith in 1917 although they had long been known to the North Slope Inupiat.

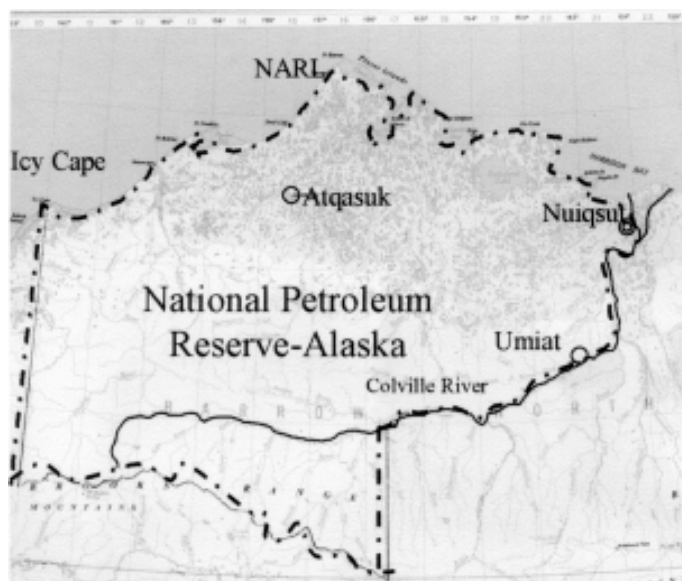


Fig. 1. Naval Petroleum Reserve No. 4 (later designated National Petroleum Reserve-Alaska), in relation to Alaska's North Slope.

Other than geologic and topographic survey parties in the area of the reserve (1923 - 1926) the area was relatively ignored until World War II. Again a wartime shortage of oil prompted President Roosevelt in January 1944 to order an exploration program of Pet 4. On 4

February 1944 the Director of the Naval Petroleum Reserves initiated the program by soliciting advice and proposals. A party was sent north on 21 March and their report recommended a full scale effort. The president authorized funds and by the end of 1944 the program was well underway. No drilling had been done but a camp was being built near Point Barrow (after Charles DeWitt Brower advised rejecting Cape Simpson) and air and communication links were established.

During the decade 1944 to 1953, 80 holes (core tests and test wells) were drilled. Most were very shallow. Three oil fields (Simpson, Umiat, and Fish Creek) and seven natural gas fields (Barrow, Gubic, Wolf Creek, Meade, Oumalik, Umiat and Square Lake) were found; all were commercially uneconomic to produce. Because an extensive program was going on and facilities were established to conduct that program other activities became possible in the region that would otherwise have been prohibitively expensive.

That was the rationale behind the selection of Barrow for the establishment of the Arctic Research Laboratory (ARL) in 1947 by the Office of Naval Research (ONR) which was established within the Office of Research and Inventions by the Secretary of the Navy under an executive order. Concurrently, feasibility discussions for the DEW (Distant Early Warning) Line were in their early stages and the Navy was looked to for answers because of the ongoing petroleum exploration. All sorts of questions were being raised about arctic operations and procedures. Vice Admiral H. G. Bowen (the first Chief of Naval Research) sent a letter to all bureaus soliciting comments on the need to establish an Arctic research program. With the overwhelmingly positive response in hand Rear Admiral Paul Lee (VADM Bowen's successor) assigned the problem to Dr. M. C. Schelsnyack. Dr Schelsnyack was at that time the head of the

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Environmental Biology Branch of ONR. A plan was drafted and approved. Dr. Schelsnyack then made a trip to Barrow in February 1947 to ascertain the feasibility of the plan.

When Dr. Schelsnyack returned, he discussed the idea with Dr. Laurence Irving of Swarthmore College. Dr. Irving was in the midst of planning an Arctic research project of his own at that time. Swarthmore, at the Navy's request, made a formal proposal to conduct research in human physiology, basic to the acclimatization of persons living in the Arctic. The proposal, submitted on 11 April 1947, outlined other areas of research (oceanography, ecology, botany, etc.) and suggested that other universities be approached. There followed a rather long and frustrating period of planning, travel arrangements, and supply, logistics and equipment negotiations.

Finally on the 6th day of August 1947, a Navy R4D (Army C-47, or commercial airlines' Douglas DC-3) landed on the pierced steel-plank runway of Point Barrow. Out of the airplane climbed seven men, led by Dr. Laurence N. ("Larry") Irving (Fig.2). The history of NARL (as it later became known) is acknowledged to have begun at that moment. Lest we imagine their moment of arrival to have felt like an historic occasion, little fanfare greeted the seven arriving scientists. The day became about as warm as it gets in the camp (10-15° C, or 50-60° F) so the group's Navy-issued cold

weather gear soon grew uncomfortable. Camp personnel were also preoccupied. Arctic contractor personnel (ARCON) had replaced the Navy Seabees in 1946. ARCON Caterpillar tractors and M29C "weasels" swarmed everywhere about the camp, preparing logistically for the annual ship resupply expedition (BAREX) upcoming within a few days of the historic arrival.

Despite their low-key reception, the group settled into their quarters (Building #259 and later that summer Building #260). They set to work measuring the oxygen consumption of cold-blooded and warm-blooded animals at various temperatures with the idea of describing metabolic needs in relation to various activities and temperature combinations. The research progressed apace as the ARL entered its first winter. Dr. Irving left in February 1948 for a few months to attend meetings and take care of some administrative responsibilities, but the research continued through the spring months. That January, Ted Mathews (who would later be a Director of ARL) arrived in Barrow as the Project Supervisor for ARCON.

In 1948, with the arrival of the arctic summer, the research program was expanded until nine projects were underway that July. Some projects were sponsored by other agencies, giving the Laboratory a national cachet. The summer was a period of intense activity and ARL scientists ranged far and wide carrying out their research or simply on reconnaissance missions. Dr. Irving went to Anaktuvuk Pass on 8 June. The people had recently moved to the tundra on the north end of the pass after spending the previous winter in the timber on the south side of the Brooks Mountains. Dr. Irving collected many specimens and recorded many details supplied by the natives. In 1947, he reported to ONR's director of Medical Sciences, "the natives are keen observers and accurate reporters, and quickly learned to prepare bird skins being invaluable in the establishment of species presence, dates, and numbers in migration." (Reed and Ronhovde, 1971:51) Irving's monthly reports are full of fascinating comments and facts, mostly attributed to the local population.

At that time, due to many administrative problems, and the reluctance of the Scientific Director of ARL to act as the Office-In-Charge (OIC) Larry Irving suggested that a governing body on policy and the selection of scientific projects be formed. Thus was created the ARL Scientific Advisory Board, in March 1948. With the coming of fall that year, the "in-residence" population of the ARL community fell to



Fig. 2. NARL's founding scientists and two Inuit colleagues, late 1947, outside the ONR Physiology Laboratory at Barrow. Clockwise from lower left: (kneeling) Reidar Wennesland; (standing) Walter Flagg, Bob Stapleton, Ray Hock, Pete Scholander, Larry Irving, Clay Kaigelaq, Joseph Ahgeak, and (kneeling) Larry's son, Larry Irving. Photo: ONR, reprinted from Scholander, P. F. 1990, *Enjoying a life in science*, with permission of the University of Alaska Press.

12 persons involved in science. It was a “routine” cold season; the following summer saw many changes.

Dr. Irving completed his tour and was relieved by Dr. George MacGinitie on 1 July 1949. This replacement coincided with the termination of the Swarthmore contract and the assumption of the management of the laboratory operation under a new contract with The Johns Hopkins University. One of the stated aims under the new contractor was to have the Scientific Director in residence for at least nine months per year.

Dr. Irving had launched the Laboratory operation and started the research program so that Dr. MacGinitie inherited a certain scientific momentum that he immediately set out to broaden and strengthen (Feder, this volume). The operation was expanded and otherwise improved, and administrative procedures were established to meet the ever-changing conditions. In the early part of Dr. MacGinitie’s administration the designation of ARL as a Naval activity under the Officer-In-Charge was rescinded.

Dr. MacGinitie, due to personal health reasons, remained as SDARL for only about 14 months. Under his aegis, research projects included insects, botany, fats and lipids, tissue analysis, parasitology, tissue metabolism, forams, geology, earth magnetic field, oceanography, marine biology, and mammalogy. The lab had grown into the multifaceted research program that it would keep throughout its operations. Federal interest in research was high at that time and the National Science Foundation was established by act of Congress.

Dr. Ira L. Wiggins replaced Dr. MacGinitie at the end of August 1950. In the fall of 1950 the ARL acquired Building #251 as a Dormitory (personnel were previously housed in Buildings #259, #262, and #263) and the connection was built between Building #250 (acquired earlier) and #251. The NARL camp by 1951 had assumed essentially the dimensions and appearance it was to maintain (Fig. 3) until the new main laboratory was built in 1968-69 (present-day Building #360). Problems were numerous when Dr. Wiggins took over but they were reasonably well identified and there was now a growing body of



Fig. 3. NARL Camp, June 1960, looking east, from over the Chukchi Sea. Photo: J. F. Schindler collection.

experience on which to base decisions. Max Brewer and Rudy Black of the USGS continued the permafrost investigations on a year-round basis in September 1950. During the following spring (1951) Project Skijump (not an ONR project) arrived at Point Barrow to make test landings on the sea ice combined with oceanographic observations. Thus the program was further broadened with other agency participation.

During this period, ONR faced many in-house problems. In the spring of 1952 there were discussions to stop all oil exploration by 1 July, with some activities to continue until the end of the year. The fate of the laboratory hung in the balance. Actually, things at the laboratory continued more or less apace until President Eisenhower on 10 March 1953, ordered the exploration program stopped. This ended the Petroleum Reserve’s direct association with the Laboratory, although an indirect influence would continue for many years. The USGS program had made some rather farsighted acquisitions of fuel, automotive parts and supplies, and these materials were a large positive factor in the continuation and later growth of the ARL. So in 1953, the Laboratory remained open and operating, and even took on some new projects and programs.

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A Year at NARL: Experiences of a Young Biologist in the Laboratory's Early Days

Howard M. Feder¹

ABSTRACT: Activities and events are recounted based on a combination of memory and journal entries by a young marine biologist living and working at the Naval Arctic Research Laboratory from June 1949 through May 1950. A three-year project of Professor G. E. MacGinitie, resident Director of NARL at the time, was designed to assess the marine environment within the waters adjacent to Point Barrow, Alaska. Those studies resulted in the first examination of shallow benthic fauna adjacent to Barrow during open-water and ice-covered seasons. The results of the study still represent, 50 years later, the most reliably complete list of taxa, and information about the reproductive phenology of many of these taxa from the area. Seasonally changing weather conditions on land and the ocean, tundra forays, beach and offshore collection activities, techniques developed to investigate the marine environment throughout the year, and personal observations are included. The account concludes with some speculations on the enduring significance and future value of this benchmark analysis of Chukchi Sea benthos.

Key words: Marine biota, collection methods, Professor G. E. MacGinitie, Iñupiat field assistants, Barrow Canyon, circadian rhythms, reproductive phenology, ice override (*ivu*), U.S. National Museum, *Mytilus*, *Halicryptus*, *Laminaria*, benthos, Chukchi Sea.

One of the most exciting years of my life began on 30th June 1949, when my plane touched down on the airstrip adjacent to the Arctic Contractors camp and the Naval Arctic Research Laboratory (NARL). I had been overwhelmed by the sight of the pack ice on the Arctic Ocean as the plane approached the landing site, and realized that after many years of reading about arctic exploration I was going to be a part of that exploration myself. I had flown in from southern California that day and was still wearing clothes fit for that part of the country, but I was too excited about setting foot on the ground of a place I had heard about for years to feel cold. Nevertheless, I was soon issued warm clothing that would enable me to live through a year at NARL. I was then taken to my home for the next year, a small cubicle in a Quonset hut (Building #263). There to my surprise, in the small common area in the front of the hut, were two radios, a phonograph and 66 classical record albums. Morgan Nordquist, a bearded construction worker and extremely interesting character, owned the music, recorded on 78-rpm records. He had lived continuously at the Camp since its wartime construction and found that only scientists at NARL appreciated his musical tastes. So he kept the records at our hut for our mutual enjoyment.

I had graduated UCLA as a zoologist with a great interest in marine biology in June of 1948. Much to my delight, shortly after graduation I was hired by Professor G. E. MacGinitie to work on his continuing project

designed to assess marine organisms living in the water adjacent to NARL and Barrow Village. Professor MacGinitie was to be the second Director of NARL, replacing Dr. Laurence Irving, while carrying on his marine research project. As MacGinitie (1955: 3) mentions in his monograph, since the arctic region in the vicinity of Point Barrow "...is about midway between ...areas ...investigated to the east and west, it was a strategic locality for the study of circumpolar distribution of species, and the extension of our knowledge of the Arctic marine animal population and its environment far to the westward." Prior to Professor MacGinitie's work at NARL, scientists knew little of the marine fauna adjacent to the coastal region of Point Barrow. Dr. Irving in one of his reports suggested, based on beach observations, that a rich benthic fauna must be present offshore.

Through the early months of 1949, and until we left in late June for our trip to Barrow, Professor MacGinitie, Mrs. N. MacGinitie and I examined and catalogued marine specimens they had collected the previous summer at NARL, and packed supplies to send to NARL for the work there. During this period they were preparing for a long-term study at NARL which included obtaining and outfitting a boat that they received from the Navy. It was a seaworthy wooden 36-footer, well suited for collecting in arctic waters. MacGinitie named it the "*Ivik*" (Fig. 1). The boat was mainly open to the elements during the summer of 1949 but was fitted with a cabin in the spring of 1950. The boat had no navigational equipment or radio. Since a compass was virtually useless in an area so close to the North Pole, all navigation would mainly depend on the dead

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Fig. 1. The *Ivik* in October 1949, before a cabin was added to the research vessel (1950). Note the fog in the background.

reckoning ability and location skills of Professor MacGinitie and the two Iñupiat boatmen, Max Adams and Chester Lampe. The *Ivik* would be transported on the annual supply ship to the Arctic Contractor camp due to arrive at the camp the first week in August.

Since it would be at least a week after our arrival at NARL before supplies could be unpacked so that sample processing and field work could begin, I was temporarily assigned to work with Dr. G. R. MacCarthy of the U.S. Geological Survey. He was mapping the depths of permafrost on the tundra. We worked in the vicinity of Elson Lagoon. The tundra was an astounding and totally different environment to a person familiar with the arid countryside of southern California. It was surprising to walk on the tundra where in most places I would sink well over my ankles until I hit the rigidity of permafrost. There was always the thought that perhaps there would be no frozen ground to stop my sinking into the tundra. Lichens and mosses were everywhere, and sedges and grasses were just emerging. We saw many jaegers (*Stercorarius* spp.) and other birds flying about, and observed a number of jaeger nests. Approaching these nests always resulted in a parent jaeger screaming and swooping down within a

few feet of our heads. I soon learned to wear a hat every time I had to be on the tundra. Lemming (*Lemmus*) droppings were everywhere, and occasionally I saw a lemming moving over the tundra. Dr. MacCarthy had wires frozen into shot holes made by seismic crews who were mapping the rock strata beneath the permafrost. The wires were at depths of 15, 30, 50, 75 and 100 ft (3, 10, 15, and 30 m). He planned to record temperatures at these depths throughout the year.

On another occasion I worked with Owen Rye, an archaeologist from the University of Alaska, on the Birnirk Mounds at the tip of the airstrip just north of the Arctic Contractor Camp. Old houses occupied by Inuit people 700-900 years ago formed these mounds. There were about 20 mounds that were 3-8 feet (1-3 m) high. The walls of the mounds were of dirt and in many of them were located wooden supports, ultimately dated by Owen Rye to be many hundreds of years old. In some of the excavated mounds were many types of whalebones and other bones. We found flakes and cores from stonework done by the people who lived there long ago. I helped Owen with his careful surveying technique where everything was mapped before objects were moved (Fig. 2).



Fig. 2. Anthropologist, Owen Rye, at excavation site Birnirk (Pigunig) on 25th August 1949.

Finally, on 11th July I was able to initiate seawater salinity and temperature readings, a task that was to continue almost daily throughout the year. A pressure ridge, still anchored approximately 1.5 miles (2.4 km) from shore, prevented exchanges of water through the ridge. Open water extended from the shore for about 50 yards (50 m). The ice between the ridge and shore was melting so that the salinity (4.4‰) was almost that of fresh water. The water temperature was 2.1° C (35° F).

Several days later in the shallow band of water between the shore and the pressure ridge we attempted to catch some Arctic cod (*Boreogadus saida*) for Dr.

Reidar Wennesland and his associate Klaus Odenheimer, both of Stanford University, for use in their work on respiratory rates of this fish. We used a small skiff to row across the narrow extent of open water. When we reached ice, which extended in broken patches from the shore to the pressure ridge, we dragged the boat over the ice until we reached a melted region and then shoved or poled our way to the ice again. At the pressure ridge, we left the skiff to search for a suitable crack in the ice to jig for the fish. We were unsuccessful with our fishing endeavors. Nevertheless, it was an exciting time for me to be out on a frozen ocean in the arctic. I did see my first seal on the ice that day. The ice was mostly solid but treacherous in spots where melting was rapid.

A week later, on 19th July, the offshore pressure ridge broke free of the bottom making rumbling sounds in the process. The next day the water was no longer calm, and ice cakes were floating alongshore and washing up on the beach. Offshore water was mixing with water adjacent to the shore so that the salinity had increased to 25.8 ‰, and the water temperature had cooled to -0.8°C (30.5°F). Salinity would now remain high and water temperatures low. As I looked out from the shore at the open water, it was difficult to grasp that only a few days ago we had been walking on ice where now only water was present. Shortly after this I collected my first marine animals (two species of jellyfishes, many amphipod crustaceans, and one vigorous large isopod, *Mesidotea* (= *Saduria*) *entomon* that had washed up on the gravel beach. No animals lived on the shore, which consisted of rounded gravel. The physical properties of the beach, periodic wave disturbance during the open water period, a tidal range of only 15-20 cm and ice scouring in winter precluded the presence of an intertidal fauna. The gravel substrate of the beach made walking difficult. I soon found that the best way to navigate the beach was to walk flatfooted, a procedure that made all future beach surveys less fatiguing. Animals found on the beach during the period of open water were removed from their subtidal habitat by the scouring activities of waves and offshore bottom currents and cast ashore. In subsequent days, I learned to search the beaches after storms or after periods of strong onshore winds. Sunlight 24 hours per day made it possible to roam the shore at any time. I was now taking salinities and temperatures twice daily. The salinity held steady at 33.4-33.8 ‰, and the water temperature usually around -0.8°C (30.5°F). Prior to the arrival of the *Ivik*, we tried to collect plankton by throwing a plankton net from the shore, but these attempts typically only resulted in collections of gravel.

Many jellyfishes were washing up on the beach by mid-July. Salinity readings were now 34.0-34.6 ‰.

The ship expedition bringing supplies to the Arctic Contractors camp and the *Ivik* (the boat Professor MacGinitie had outfitted in California) arrived the first week in August. Once the *Ivik* was offloaded and operating, we began making offshore sampling hauls with a dredge whenever sea and weather conditions permitted. The boating period between early August and 14th October 1949 was a busy one for all of us associated with the project. After animals were brought into the laboratory following collecting trips, intense activity prevailed for a number of days. Most specimens had to be fixed and preserved as soon as possible, and placed in bottles with labels that included tentative identifications and locations of the collected samples. This procedure often meant working day and night until all samples were processed. The sorting process continued throughout the year. Mrs. MacGinitie maintained scrupulous records of all animals collected and stored prior to shipment to various taxonomists. Mrs. MacGinitie did the taxonomic work with the mollusks in the collection, and published her results in a monograph of the group (MacGinitie, 1959). Additional taxonomists who worked with other groups are as follows: Foraminifera: Loeblich and Tappan, 1953; sponges: de Laubenfels, 1953; turbellarian flatworms: Hyman, 1953; nemertean: Coe, 1952; polychaete annelids: Pettibone, 1954; bryozoans: Osburn, 1950, 1952, 1953; cumaceans: Feder, unpub. and Given, 1965; Mysidacea and Euphausiacea: Banner, 1954; amphipod crustaceans: Shoemaker, 1955; tunicates: Abbott, 1961. All other groups were either identified by Mrs. MacGinitie from the literature or with the assistance of taxonomists from various scientific organizations (W. K. Fisher of Hopkins Marine Station of Stanford University: Sipunculida and Priapulida; W. L. Tressler: Ostracoda; Paul Ilg of the U. S. Nat. Museum: Copepoda; Robert Menzies: Isopoda; Fenner Chace of the U. S. National Museum: decapod crustaceans; Dora Henry and E. G. Reinhard: the barnacles. All of the above taxonomists identified numerous specimens for Mrs. MacGinitie prior to their inclusion in publications. In some cases, no publications would be forthcoming. Nevertheless, the taxonomists graciously provided taxonomic identifications that would assure the completeness of the MacGinities' final reports and monographs. Professor MacGinitie took pictures of as many animals as possible, prior to preservation, in order to record the colors of live organisms so taxonomists could add color references to their descriptions of new species, of which there were many (Fig. 3). Most of his color slides were



Fig. 3. *Echiurus echiurus*, a specimen belonging to a phylum known as “spoon worms,” collected near Barrow in October 1949: an example of photographic documentation of marine invertebrates by Professor and Mrs. MacGinitie.

submitted to the U. S. National Museum at the Smithsonian Institution. Animals that could be maintained overnight were placed in a cold room to extend the time available for photography. Occasionally animals would freeze in that room, but some thawed when brought into the laboratory and still appeared viable.

In mid-August numerous capelin (*Mallotus catervarius*), a small fish about the size of a smelt, began spawning and laying eggs in the gravel adjacent to the beach. This fish does not spawn on the beach above water as does the grunion (*Leuresthes tenuis*) in California. The capelin frequented the shallow inshore waters for several weeks in such large numbers that they were readily taken by sweeping long-handled nets through the water. This was a traditional supplemental food resource that people from Barrow Village annually netted in large numbers. Klaus Odenheimer and Chester Lampe collected fish for use in the physiology laboratory during this period (Fig. 4)

Initially the *Ivik* was anchored offshore but as September approached, the water became more and more turbulent. On 2nd September, after Professor MacGinitie and John Huff (NARL’s versatile machinist and mechanic) were overturned twice in their skiff in the surf while trying to reach the *Ivik*. Although he did not complain to anyone, Professor MacGinitie sustained a serious hernia as a result of the violent efforts required to right the skiff in the surf and pull the skiff onboard the *Ivik*. Nevertheless, he and John Huff managed to negotiate the rough seas and bring the boat to the shelter of Elson Lagoon. It remained there until the sea calmed sufficiently to return it to camp where



Fig. 4. Inupiat family from Barrow village fishing for capelin, August 1949, between Barrow and the NARL Camp.

it was pulled on to the beach well above any surf activity. Professor MacGinitie subsequently decided to pull the boat up on the beach with a “Cat” after all future dredging forays. As September progressed the surf breaking onshore made it more and more difficult to launch the *Ivik*, but a number of successful dredging trips were accomplished. Each return of the boat to the beach was a wet and invigorating experience for the boat crew because we had to work in the surf to attach the bow hook to the “Cat.”

When the surf was exceptionally heavy in September, numerous invertebrate animals and occasional Arctic cod washed onshore. Evening walks along the shore became a daily routine to see what interesting animals might be found. Some of these walks were made all the more pleasurable and intellectually interesting by having Dr. Ira Wiggins, the future Director of NARL, with me. On several occasions thousands of amphipods washed ashore in long windrows extending north and south as far as the eye could see. In some places these windrows formed layers of animals up to two inches (5 cm) deep in depressions on the beach. On one occasion Professor MacGinitie brought a few slices of bread with him and made a sandwich of amphipods. He reported them to be crunchy but tasty. No one else joined him in his repast. Many other animals were found on the shore during September—hydroids, bryozoans, polychaete and echiurid (Fig. 3) worms (*Echiurus echiurus*), priapulids (*Priapulius caudatus*), nudibranchs, snails, amphipods, cumaceans, euphausiids, hermit crabs, shrimp, sea cucumbers (*Myriotrochus rinki*), and tunicates (*Rhizomolgula globularis*). The animals had obviously been recently torn from the substrate prior to washing ashore; consequently, the original colors of the living animals were still observable. These collections opened a

window to the richness of the shallow sea-bottom adjacent to the shore (as suggested the previous year by Dr. Irving). Chester Lampe mentioned to me that people from the village often ate echinurid worms (Fig. 3). They would cut off the posterior region bearing setae or bristles, discard the internal organs and either eat the remaining portions of the animals immediately or take them home to be eaten fried. On another evening around dusk on a trip to Point Barrow, I noticed a line of blue-green luminescence along the shore as far as the eye could see. Close examination revealed the presence of huge numbers of small euphausiid crustaceans mixed with algal material. The luminescent organs of these crustaceans were responsible for the light on the shore.

On occasions when the sea was calm in the evening a companion and I would row offshore to haul a small plankton net to collect water-column specimens (zooplankton) for the MacGinitie collection. Occasionally, when surf was reduced or absent, I was able to make a successful net cast while beach walking. On one of these calm nights we witnessed an incident that amused us (although participants in this incident were distinctly not amused). A group of people from the village came down the coast in their *umiak* on the water. They were being pulled along by a team of their sled dogs running onshore just above the waterline. Shouts from the boat encouraged the dogs, as the helmsman guided the *umiak* along smoothly, keeping it about 30 feet (10 m) out from the shore. At the approach of the team, dogs tied up or loose within the Arctic Contractor Camp set up a chorus of howled greetings or threats. Immediately the orderly scene disintegrated. The working dogs started running toward the camp dogs, pulling the boat onto the shore—ignoring the angry shouts of the men on the boat. With dogs running up the beach dragging a boat load of screaming people over the bumpy beach and men leaping out of the boat while yelling at the dogs we thought the scene had all the ingredients of slapstick comedy.

The surf became more turbulent toward the end of September and began to scour the shore, often resulting in formation of a longshore ledge of gravel up to 0.5 m high. The waves typically moved along the shore at an angle, shifting the gravel on the beach so that the appearance of the shoreline was constantly changing. Numerous animals were washed up on the beach during this period, including sea anemones, polychaete worms, amphipods, cumaceans, small clams, small sea cucumbers, a small sand-covered tunicate (*Rhizomolgula globularis*), and a few eel pouts

(Zoarcidae). An attempt to move the *Ivik* through the surf on September 27 was unsuccessful as the waves turned the boat broadside, the rudder slipped off the boat and snapped. As usual, while we were involved in launching and then retrieving the boat, we became soaked by cold seawater measuring 0°C. The rudder was repaired, and a number of successful dredging trips were accomplished in subsequent days when the ocean became less turbulent.

During the last few days of September, the sea was calm and the water clear for the first time in many weeks. Large numbers of medusae were observed floating close to shore. A plankton haul from the beach revealed many small medusae, a few chaetognaths (arrow worms), an extraordinary abundance of copepods and a few mysid crustaceans (*Mysis*). Numerous phalaropes (*Lobipes*, *Phalaropus* spp.), apparently responding to the relatively placid water, were observed bobbing up and down in the gentle swell about 250 m offshore. In the evening while I was taking water samples, a snowy owl (*Nyctea scandiaca*; my first view of one) flew by and landed on *Ivik*'s mast on shore. Apparently the owl had been feeding on a freshly killed eider duck on the shore when my arrival disturbed its feeding activity.

On 1st October, Professor MacGinitie collected three translucent squid (*Gonatus fabricii*) on the beach near Point Barrow. One was still alive when he brought it into the laboratory, and it promptly bit him while he was showing it to us. Several days later, while walking on the beach in a snowstorm, I spotted a squid that had washed up on the shore. I had a husky puppy with me, and he spotted the squid at the same time as I did. Needless to say the pup reached the squid first, and ate it with great relish. In subsequent days the air temperatures remained below freezing. Consequently, gravel on the beach became frozen in place, making it possible to walk without struggling through soft gravel when searching for animals washed onto the shore. The beach and adjacent tundra were now covered with snow.

On 4th October, Hoover Koonaluk and I went to Elson Lagoon to pull in a gill net he had left in the water overnight. A single, large sculpin (*Myoxocephalus quadricornis*) and many amphipods were in the net. People from Barrow Village often caught this sculpin in nets in the Lagoon, and occasionally collected it along the ocean shore. The fish has a large head and slender body with little flesh available as food, but in the 1940s people from the village did not turn down anything edible that could be gleaned from the

environment. Hoover took his kayak out on the Lagoon and pulled a plankton net for me. The collection flask was filled with ice crystals and large numbers of copepods. The edge of the Lagoon was starting to freeze. As we went back to the laboratory, we saw numerous large medusae washed ashore. Additionally, we collected a number of frozen animals on the beach: a polychaete, echiurid worms, several nudibranchs, some amphipods and several hermit crabs. When we took the frozen animals to the laboratory, we were surprised to see the polychaete, one nudibranch and the hermit crab move about shortly after immersion in cold seawater.

On 6th October, the sea was calm with only small swells. The air temperature was just above freezing which seemed very warm to us. In fact, Dr. Jack Wickham, an oceanographer from the Scripps Institution of Oceanography in southern California, suggested that it was almost like being off of La Jolla, California. We pulled the *Ivik* into the water, and traveled about five miles (8 km) offshore to a region with a depth of approximately 116 feet (33 m). Our dredge hauls indicated a rocky and boulder-strewn seafloor at that location. Consequently, the animals present in all hauls were primarily sessile forms attached to the rocks—sponges, hydroids, bryozoans and tube-dwelling polychaete worms. A live, gravid orange-colored octopus (*Benthoctopus hokkaidensis*) about 1.5 ft (0.5 m) in length came up in one of the hauls. This specimen had been previously described from Japan, the Okhotsk Sea and the Bering Sea. The animal from the Barrow region extended its range into the Arctic. As in previous boat operations, we typically had two oceanographers on board, on this day it was Dr. Wickham and L. D. Hoadley of Woods Hole Oceanographic Institute, who deployed a Nansen bottle and a bathythermograph. As the day progressed, air temperatures decreased to -6.5°C and the wind increased. Any clothes that had become wet during dredging operations soon became frozen. Dr. Wickham soon withdrew his comments about the balmy weather he was experiencing on the Arctic Ocean. We kept the octopus alive for several days in our cold room where the seawater temperature measured -0.8°C .

During the first few weeks of October air temperatures were variable, and generally hovered between 0° and -7°C with accompanying weak to strong winds. Although I did not find it necessary to wear a parka during this period, the following assortment of clothing indicates that I did need to bundle up to stay comfortable—wool underwear, wool army shirt and pants, a flight jacket, wool hat (on shipboard a hat with ear flaps), rubber

boots with felt liners, two pairs of wool gloves, and a scarf if a strong wind was blowing.

On 10th October, long swells were seen on the ocean moving in from the southeast. Mist was rising from the water surface, which limited visibility over the ocean to only 100 m. A strip of ice about 3 m wide was forming alongshore as far as the high water mark. Water temperature was -0.8°C .

We only went out with the *Ivik* two more times that year, on the 11th and 14th October. On the 11th, a calm, relatively warm day (27°F ; -3°C), we took the boat eight miles (12 km) northeast of Barrow base (site of NARL). We passed phalaropes and eider ducks (*Somateria molissima*; *S. spectabilis*) while underway. We dredged at 453 feet (140 m) on a rocky bottom very rich in fauna—sponges, polychaetes, bryozoans, brachiopods, clams, snails, shrimps, the crab *Hyas*, the sea cucumber *Psolus*, the basket star *Gorgonocephalus*, tunicates (a variety of species) and a fish. A similar haul was made at 341 feet (110 m). Frost was observable on the rigging on the way back to base. On 14th October, the last boat trip of the year (Fig. 1), four dredge hauls were made approximately 5 miles (8 km) offshore at a depth of about 171 feet (55 m). I noted that as I tied a knot on a line my hands became numb in less than three minutes. The hauls consisted of many animals similar to those of the previous trip, although there were many small clams and clamshells in the material. When we returned after that last trip, the boat was hauled out of the water and placed next to the laboratory building where it remained until the following summer. Boating activity as late as the middle of October 1949 was possible only because the ice pack was still over 100 miles (160 km) distant from shore. The Barrow Inuit could not recall this happening in the past. They said that the ice pack typically returns close to shore by the beginning of October.

Occasionally in summer, people from the village or one of the construction workers from the camp would find some odd animal and bring it into the laboratory. On one occasion we were told that small turtles had been collected in a tundra pond. We were initially astounded by this announcement since reptiles were not reported from Alaska or other arctic areas. When they brought the “turtles” to us, we were disappointed to see that they were small crustaceans known as tadpole shrimp (Class Branchiopoda), a group whose bodies are half-covered by a large, shieldlike carapace. In summer, these and other small crustaceans (e.g., the fairy shrimp *Eubrachipus*) are common in tundra ponds. On another occasion, one of the construction

people brought in a 7-month old wolf that he had raised from a puppy. The wolf was close to full-grown and had started to intimidate its owner with rather aggressive behavior. We accepted the wolf and tied it temporarily to the refrigerator door. It was so aggressive and active that we were unable to open the door when we wanted something inside the refrigerator. Since our expertise was with invertebrates and not mammals, we soon gave the wolf to one of the scientists in the vertebrate animal quarters.

Although I had witnessed auroral activity since mid-September, the display on the night of 15th October was the most spectacular I had seen. It was a combination of the curtain type of display (with as many as three simultaneous curtains) and the writhing ribbon type. Colors representative of the entire spectrum were observable. At times most of the sky was filled with a shimmering, glowing, ever-changing light. At other moments a few light green streaks were seen which developed slowly in a rapidly expanding glow of color. In the subsequent dark months ahead, auroral displays would be my constant companion on the daily forays to obtain water samples. Auroral displays were especially awe inspiring to me as they undulated across the dark sky above white, irregular ice shapes gleaming under the stars or a bright moon. I frequently paused for long periods while sampling to more fully appreciate the beauty, peace and quiet within this icy environment. It was at moments like this that I recognized how fortunate I was, a person who had spent most of his life in crowded, noisy urban environments, to be living this unforgettable arctic experience.

A family of four husky pups and their mother took up residence under my Quonset hut in October. It was enjoyable to play with the puppies, and hear various puppy sounds under the hut at all times of the day and night. I finally named the puppies: Ookpik (a female), Okluk (a female that looked like a bear cub), Nanook (white and black male), and Sik Sik (a dark-colored male, my favorite that I retained until I left NARL in June).

On 16th and 17th October tall and powerful swells rolled in along the coast, breaking 20-25 yards (20-25 m) from shore. This strong turbulence brought large numbers of animals onshore to add to an ever-expanding collection. Sea stars *Solaster* (the sun star) and *Leptasterias* as well as a great variety of other species were collected. At the tip of Point Barrow the surf was especially rough and ice cakes were accumulating on the beach. The tundra at the Point was eroding away as a result of the heavy surf typically present there.

Numerous artifacts appeared at the site as the exposed permafrost melted around them. Near the Point I was able to examine the remains of an old Inupiat village. Deep ice cellars with whalebone bracing were visible. The remains of a number of houses constructed of peat moss and sod were still identifiable. Close to the Point was an old seal and whaling station where the heavy surf had thrown hundreds of the echiurid worms, pteropods and other animals onto the shore. An old man who lived permanently at this camp brought out a lamprey eel (*Lampetra*) that he had found on the shore. It was about one and one half feet (0.5 m) in length, and represented the only lamprey that had been observed in the vicinity of Barrow. Another trip to the Point with the MacGinities several days later revealed a frozen beluga whale (*Delphinapterus*) that had washed up on the shore. It was 12 feet (4 m) in length. We examined the eroding tundra by the old village for exposed artifacts. We noted an animal hide, wood, bone fragments, and three small bones neatly tied together with cord.

In mid October, Dr. Reidar Wennesland and I decided to try our ice skates in the brackish water lake behind our living quarters. The ice was firm but the snow crust was about two inches thick and very hard. We had considerable difficulty trying to remain upright on the crusty substrate, and gave up after 20 minutes. Late in October Dr. and Mrs. Robert Black (scientists from the Geological Survey, L. D. Hoadley and I tried skating on a freshwater lake behind the camp airstrip. The wind had blown most of the snow off the ice, and the skating was satisfactory if we confined ourselves to areas without a hardened snow crust.

Large flocks of eider ducks and oldsquaw ducks (*Clangula hyemalis*) were still flying alongshore on 19th October. Numerous Glaucous (Point Barrow) Gulls (*Larus hyperboreus*) and phalaropes were also still present along the shore. Snowy owls were observed on the tundra, and one of the men at one of the inland test wells said that he had seen up to 30 snowy owls near his living area.

By 24th October slush ice was forming on the ocean surface and alongshore a frozen ledge of ice was forming. The seawater temperature was -1.8° C In the afternoon we went out in a small skiff and outboard motor to collect plankton with a small tow net. We went out about one mile and noted vapor rising from the water around us. The plankton sample contained numerous diatoms and a great variety of larvae (Polychaeta, Mollusca, Crustacea), small medusae,

chaetognaths, pteropods, and copepods. Many large medusae were present in the surrounding water.

Several months of observation had shown me how unpredictable the Arctic Ocean could be, and I began to understand how quickly that body of water could change its physical appearance. Thus, for several days the ocean could be as calm as a lake, and skiff activities would be pleasant and productive. By contrast, on other days waves would pound the shore and scour the shoreline. Some of the larger waves on these days would break 20-25 yards (20-25 m) offshore. The surf on such days was always dangerous because it generally came in at an acute angle to the shore with a powerful, sweeping surge. Boat work on such days would not only be unproductive but foolhardy as well. Needless to say skiff activity was never attempted under such conditions. Additionally, the unexpected and very rapid development of fog over the ocean, with the resulting limited visibility, always made offshore boat work hazardous (Fig. 1). By late October an ice shelf up to 1 1/2 feet (0.5 m) high, a result of water freezing the loose sand and gravel together, was forming at the upper limit of the surf zone.

On 27th October, the pack ice was about 40 miles (25 km) offshore but was moving in rapidly. Several days later as I went to the shore for the daily water sample, I noticed that ice was visible no more than two miles from the shore, extending north and south as far as I could see. A view with field glasses suggested that the ice consisted of cake ice, probably drifting ice derived from Elson Lagoon and other embayments along the coast. Professor MacGinitie, Hoover and I went out with a small skiff and confirmed that the ice consisted of innumerable cakes of varying size with a thin, frozen matrix insecurely holding the ice together into a floating mass. The ice extended to the horizon and north and south as far as I could see. The water temperature was 28° F (-1.7° to -1.8° C). I took three plankton hauls. It was apparent that I was acclimating to low temperatures since I had my gloves off most of the time, and, although my hands became cold, I was not uncomfortable. A plankton haul from the skiff revealed a great variety of diatoms, planktonic larvae, ctenophore fragments, chaetognaths, ostracods, copepods, mysids, euphausiids and a few juvenile arctic cod.

On 1st November walrus were spotted on and around offshore ice cakes. Professor MacGinitie, Hoover and I took our skiff out to observe them. Professor MacGinitie recorded their presence with his motion picture camera. We came within 25 yards of a young walrus who initially just stared at us but soon became

alarmed and clumsily moved off the ice cake. We moved around the ice cakes, occasionally spotting other walrus in the water and on the ice cakes. Hoover was very nervous during this period, and said it was dangerous to be around swimming walrus while in a small boat. So, we took a plankton haul and went back to the shore.

By 5th November, the ocean from shore out to about 35 yards (35 m) was white with slush ice. Small waves were pushing slush ice onto the beach to form a mass 15 feet (3 m) wide and up to four feet (1.3 m) thick in places. The sediment suspended in the turbulent water alongshore made it necessary to strain the water samples. It had been snowing every night for the past two weeks so that snow was building up on the upper beach and adjacent land. In the next few days, floe ice moved to the shore and mixed with the longshore slush ice so that ice could now be seen in all directions. On November 10 we went out in a skiff to put out fish traps designed to catch arctic cod. The traps were oil drums with lead-in cones of chicken wire screen with meat scraps and chicken viscera as bait and floats for future location. They were dropped from the skiff 25 ft (8 m) from shore and marked with floats. Although it was possible to maneuver the skiff among the ice cakes, strong southeasterly winds and associated currents made it difficult to hold the boat in place while sampling for plankton and pulling fish traps. The traps were left in place for about 12 hours, but rarely had fish in them.

By 12th November the days were becoming shorter and the sun was never very far above the horizon. It could be seen along the horizon as a red ball. Boat activity was now restricted to only a few hours a day since it was dark by mid-afternoon.

On 14th November, the MacGinities left Barrow for meetings in the Lower 48 and surgery for Professor MacGinitie's hernia. I remained at NARL to continue the seawater-sampling program, collect animals before and after freeze up and continue to catalog samples collected to date. On this day I noted that the offshore ice was building up and appeared to be grounding. The water surface was always covered with slush ice now, and water samples would start freezing as soon as I collected them. As I was collecting samples today, I observed three ducks swimming in a small offshore ice lead about 150 yards (150 m) from shore.

As of 16th November, ice cakes were piling up along the shore and freezing together from the shore outward. By 17th November the water between the ice cakes was frozen up to 6 inches (15 cm) thick, although some

offshore leads were still observable. Ice cakes were pushed on shore during the night. Most of them were a blue-green color characteristic of new ice. This was the first day that I was able to walk out on the ice to take a water sample, but it was now necessary to chop a hole in the ice to obtain water. Water temperatures were now a consistent -2.0°C (27°F). I had switched my footgear to winter mukluks made by Chester Lampe's wife, and found that my feet were very warm at an air temperature of $+2.7^{\circ}\text{F}$ (-16°C). I was so impressed with Mrs. Lampe's skin work that I ordered a pair of slippers for a lady friend at a college in California. When my friend received them, she thanked me but mentioned that she was banished from her dormitory as soon as she wore them. I soon found out that the skins used by Mrs. Lampe were cured with urine. Fortunately I was not banished from my lady friend's life, and we were married several months after I returned to California in June 1950.

Strong offshore winds in subsequent days opened leads between the offshore ice and the shore, and it became unsafe to walk on the ice for sampling. Nevertheless, I found open water suitable for sampling along the shore southwest of NARL. In this open water I collected three types of jellyfishes. The largest of these, *Chrysaora*, contained eggs and was liberating developing eggs and planula larvae (verified by microscopic examination in the laboratory) into the water. A duck was observed floating and surface diving on a small, offshore lead. By 20th November the open water between the offshore and shore ice was frozen again but was only about 1-2 inches (2.5-5.0 cm) thick. The ice close to shore, however, had thickened sufficiently to make it possible to walk out 25 yards (25 m). A hole bored in that ice measured 11 inches (28 cm) in thickness. Offshore, in a lead south of the NARL camp, 30 ducks were floating in the ice-encrusted water, surface-diving and apparently feeding. Small amphipods were observed on the bottom through open areas of broken ice, and the ducks may have been feeding on these crustaceans.

From 21st to 23rd November, strong onshore winds introduced me to the type of conditions to be expected throughout the winter. Winds ranged from 45-55 mph (70-90 kmh) with occasional gusts up to 63 mph (100 kmh). While drilling holes in the ice for water samples, I had difficulty maintaining my balance in the strong wind. This was my first opportunity to practice walking against the wind at a 45° angle, a survival technique that personnel at NARL quickly learned. Seawater temperatures continued to be -2.0°C with the salinity approximately 34 ‰. The air temperature during this

period decreased to -18°F (-28°C). It was soon apparent that weather conditions were becoming more extreme than I had experienced up to now. I often noticed that my nose became numb very quickly while air that I inhaled made it difficult to breathe. The increasingly harsh weather conditions and strong winds made trips from my Quonset hut to the wooden building known as T1 (the location of shower and toilet facilities for serious needs—the facility in the building consisted of holes cut in planks with a 50 gallon drum underneath) a major adventure, and one undertaken in subsequent months only when absolutely necessary. Fortunately, steel helmets strategically located at the back of my Quonset hut served less serious toilet requirements.

By late November the offshore ice was approximately 1.5 feet (0.5 m) thick, but a lead could be observed one mile offshore. Cracks and small leads periodically opened parallel to shore but quickly froze over. It was through holes made in the relatively thin ice of these frozen leads that I obtained water samples for the next few weeks (Fig. 5). A trip to Elson Lagoon demonstrated that this shallow body of water was frozen almost to the bottom near the shore. No animals



Fig. 5. Marine sampling through thin ice over a refrozen lead, late autumn 1949.

were collected through the ice there. I noted that there were no longer any “true” days at this time of the month. It became light enough to see one's surroundings by 10:30 am local time, but full darkness returned by 1:30 pm. [Editor's Note: By convention, Barrow's local time zone in 1949 was one or two hours further behind Greenwich Mean Time than is today's convention. The symmetry recorded here in extent of light levels either side of local solar noon, is no longer the case today, because solar noon in winter, or non-daylight savings time, falls at about 1:30 pm.] The sun was now only a red glow on the horizon. As the sun

“moved” along the horizon, red, orange and gold colors tinged the sky. Whenever I sampled during this period, I had to make a hole in ice that was now 14 inches (36 cm) thick. I initially used two tools—a pick and an ice chisel about 6 ft (2 m) long. Later, when the ice was about 2 feet (60 cm) thick, I switched to a manually operated ice drill to reach water. This was considerably easier than chopping a hole in hard ice every day. On some occasions, I went out on the ice with the two physical oceanographers from Woods Hole Oceanographic Institution. (L. D. Hoadley and D. M. Owen) who were also collecting seawater and measuring ice thickness. On other days, I accompanied Chester Lampe and Pete Sovalik when they went out with fishing gear (of the type used by people in the village; i.e., hooks on a line and jigging in holes in the ice to snag the fish) to catch Arctic cod for possible use by the physiology group in the laboratory. They were typically successful in their fishing endeavor as opposed to the lack of success of the traps we had deployed in the past months. Unfortunately, most of the fish they caught this way were usually damaged by the process and/or frozen when retrieved from the hole. Thus, it was necessary to continue to use traps rather than jig for the fish. By using traps, we could carefully and rapidly remove fish from the traps and avoid freezing by immediately placing them in large containers of water for transport to the physiology laboratory. Traps avoided injuries that fish sustained by the jigging approach.

When limited light conditions precluded spending more than an hour or two on the ice, I spent more time inside the Laboratory (Fig. 6) sorting specimens and preparing them for ultimate shipment to the U. S. National Museum. Additionally, I started to spend time in the Laboratory’s darkroom, printing photographs that I had taken during my stay at NARL. Morgan Nordquist had an excellent collection of negatives obtained from other photographers. His negatives bracketed the time that whaling ships visited and overwintered at Barrow, showed Inuit families working and hunting, and documented the visit of Sir Hubert Wilkins to Barrow following his under-ice submarine adventure. I spent many happy hours in the darkroom printing these negatives.

With this shift to indoor activities, I noted that my sleep habits had changed now that it was dark most of the time. I found that I now involved myself in laboratory and darkroom pursuits until I felt tired enough to sleep. When I checked to see how this was affecting my wake-sleep pattern, I found to my astonishment that each day I would go to sleep 1-2 hours later than the



Fig. 6. Main Laboratory at NARL Camp, as it appeared at local noon on 27th December 1949.

previous day and would wake up 1-2 hours later the following day. I was soon cycling in a classic circadian pattern. On some occasions I was awake when the rest of the camp was active and could have meals at the Camp Mess Hall. At other phases of my circadian cycle, however, I was awake when everyone else was asleep and had to forage for food, using table scraps stored away for such occasions. I continued this pattern through the long, dark winter.

On 2nd December, while collecting a water sample, I saw a large flock of eider ducks fly by over the ice. Chester Lampe told me that these birds may remain in the area until the end of December, feeding on large isopods (*Mesidotea* or *Saduria*) in the open water lead about 2 miles offshore. Abundant amphipods on the bottom may also have sustained these ducks. It was around this time that I started to see dog sleds on the ice, usually operated by young boys between the ages of 12 and 18. Air temperatures in early December varied between -21° to -35° F (-30° to -37° C), and the sea ice was now up to 23 inches (58 cm) thick. I started to wear the white felt boots (“Bunny Boots”) that Sir Hubert Wilkins introduced to arctic explorers and investigators a number of years prior to my time at NARL. Although they were awkward to wear at first, they kept my feet warm and comfortable despite the low temperatures. I also began wearing extra wool liners in my leather gloves but my thumbs still remained cold when I was sampling on the ice. The moon was now visible most of the 24 hours per day as a very bright object in the dark sky. The moonlight reflected from the frozen ocean gave the ice blocks and pressure ridges an unearthly look. These few hours of daylight could be compared to light at dawn just before the sun

risers at lower latitudes. The sky on the horizon was red throughout those few hours as the glow moves from east to west along the southern horizon.

On several occasions in early December, I accompanied Dr. and Mrs. MacCarthy in a weasel (a tracked, motorized vehicle used to travel over snow and ice) to their temperature monitoring station southeast of Barrow Village. The air temperature on one trip was -18°F (-22°C) with winds gusting to 40-45 miles per hour (70 kmh) greatly increasing the wind-chill factor. It was difficult to work outside of the vehicle. Visibility was poor as a result of the fine snow particles blown into the air by the wind and the reduced light. The so-called whiteout conditions were extreme, and it was not possible to determine the white snowy substrate from the white sky. Under such conditions it would be possible to drive off a precipice without recognizing its presence. Earlier in the winter Dr. MacCarthy had placed red-flag markers along the route. Without these markers it would have been virtually impossible to drive with safety, locate his station and return to NARL. I estimated the visibility to be about 150 feet (50 m). Even with these navigation markers, I frequently had to get out of the vehicle, walk slowly ahead of it until I could see a flag, and then signal back to Dr. MacCarthy so that he could move the weasel ahead.

One Sunday in mid-December at about 1:30 pm local time, John Huff (the NARL machinist) and I took a walk out on the sea ice. We went about a mile (1.6 km) offshore and then half a mile (0.8 km) toward Barrow Village. The ice consisted of smooth ice sheets mixed in with jumbled piles of ice cakes. In some areas large ice blocks extended about 25 feet (8 m) above the ice surface. We returned to Camp by 2:30 at which time it had become so dark that it was difficult to walk. In retrospect, it is interesting to me that polar bears were not considered a threat to anyone walking about on the ice near shore in 1949. Bears were rarely observed close to shore and our little outing was not considered dangerous or foolhardy at that time (for contrast, see observations of a polar bear within Barrow village in late January, below).

In mid-December the extreme variability of air temperature to be expected in the Barrow region became apparent when temperatures reached a balmy -2°F (-18°C) and ultimately reached $+10^{\circ}\text{F}$ (-12°C). It felt so warm that I stopped wearing a parka and put on a light flight jacket. Pete Sovalik mentioned that people from the village were killing “lots of seal” about two miles offshore adjacent to a lead in the ice. He said

that seal hunting in winter was good because the seals would float at this time of the year because of their great accumulation of blubber, whereas in summer they would generally sink when shot.

During the night of 26th December, sea ice was pushed onshore to form an override, or ice shove (*ivu*), extending all the way from the Point to Barrow Village. The vertical height of the ridge measured between 10 and 15 ft (3-5 m). The ridge consisted of great blocks of ice 3-4 ft (1-1.2 m) thick and up to 7 ft (2.2 m) at their greatest width. Continuing onshore winds ultimately pushed the ice approximately 18 ft (6 m) further up the shore. Measurements indicated that the ice had pushed up to 80 feet (27 m) inland from the water's edge (Fig. 7). Chester Lampe told me that it was not safe to cross this ridge to take water samples for a few days until the ice became stable. When it was possible to cross the override ridge to obtain water samples, I was immediately impressed by the size and extent of the mass of ice shoved on the beach. It extended north and south as far as the eye could see. On the seaward side of the ridge the sea ice gradually tapered up to the ice mass but on the shoreward side it dropped off sharply. The ice mass almost completely hid the Camp so that from the seaward side of the ice ridge only antennae and towers were visible.



Fig. 7. Ice pileup along Chukchi Sea shoreline as it appeared on 2nd January 1950, a week after the *ivu* (ice override) event that drove ice ashore.

Through the early weeks of January most of my time was devoted to sorting and labeling material previously sampled on the beach or dredged by boat the previous summer and fall. The collection by the MacGinities had become quite extensive by this time and required constant curatorial attention. Professor and Mrs. MacGinitie returned to NARL on 12th January, and immediately began their joint administrative and

scientific tasks.

Professor MacGinitie wanted us to be able to cut large openings in the ice so that fish traps, dredges, plankton nets and oceanographic gear could be deployed throughout the winter. The Laboratory's brilliant and knowledgeable machinist John Huff designed and constructed an ice-cutting device during December and January. Initially he considered steam to be the best approach to cutting through ice, but Huff calculated that jets of boiling water would be more efficient and less dangerous than a steam-driven system. The completed apparatus initially utilized a gasoline fire within an oil drum to heat seawater circulating through pipes situated within a larger surrounding drum. A pump removed water from a reservoir tank that held about 35 gallons (130 litres) of seawater, and continuously circulated water through the pipes and the reservoir tank (Fig. 8). Once it was determined that the circulating water was reaching the boiling point, a valve was opened and the hot water directed into a pipe. The hot water passed through the pipe, and exited through a series of small holes in a pipe welded at right angles to it. The pipe with the exit holes was approximately 1.5 feet (0.5 m) wide. Ultimately the hot water delivery unit was redesigned as a pipe frame consisting of two pipes directing water to the exit pipe containing the holes. The pipe frame was easier to handle than the single pipe.



Fig. 8. Ice-cutting device designed by John Huff for Prof. MacGinitie, as it appeared early in 1950.

The procedure for using this heating unit involved pulling the sled-mounted cutter (Fig. 9) to a recently frozen lead where ice was relatively thin. The unit was typically pulled to the site with a weasel but occasionally conditions required that we push and pull the unit to the site. We then bored through the ice with an ice auger. An ice chisel was used to form a hollow around the



Fig. 9. Sled-mounted boiler device, and weasel used to tow the ice-cutter to stations out on the landfast ice of the Chukchi Sea, early 1950. Jacob Stalker, under the tarp, thaws the pump with a blowtorch.

hole, which filled with seawater. A bucket brigade moved water from the hole to fill the reservoir tank (Fig. 10). The water in the reservoir served to prime the pump so that water could be sucked from the reservoir tank through the pipes of the heating unit. Once the oil-heating unit was started, we placed canvas over the pump and used a blowtorch to thaw out the pump (the pump was always frozen when we arrived on site, and during the test period it was decided to use a blow torch as a thawing device). After warming, starting and priming the pump, water circulated between the reservoir tank and the heating coils until it was close to the boiling point. We then opened a valve to allow water to flow into the pipe and water delivery unit. As soon as water began flowing through the holes, the unit was held against the ice. The hot-water process was very efficient, and cut through ice at approximately a



Fig. 10. Dipping water to fill the reservoir to start the ice-cutting device. Photo, R. F. Black.



Fig. 11. Jacob Stalker and Hoover Koonaluk applying the hot water-filled cutter tube, to melt a sampling hole in the sea ice.

foot a minute (30 cm per min). Openings in the ice 3 ft by 3 ft (1 m by 1 m) were made in this way through the relatively thin ice (2-3 ft thick) of re-frozen leads (Fig.11). The ice block made by the cutter was then pushed down manually, with great difficulty, until it slipped sideways under the adjacent sea ice and was carried away by the water current. Trials began in mid January but the first successful deployment of the cutter did not occur until 24th January.

In January the sea ice was frequently under stress as a result of offshore winds, and leads were detected well offshore by darkened skies above them and clouds of vapor rising from the exposed water. Also, during this period pressure ridges formed from time to time. Our safety from the dangers of lead and pressure-ridge formation was enhanced by the advice and counsel of Chester Lampe, an Inuit with long-term experience in the arctic, who informed us when on-ice activity would be risky. He was typically correct in his assessment of ice conditions, and ice leads and pressure ridges often formed on days when he suggested that we avoid working on the ice.

Sampling through the ice during December and January generally occurred in the dark by moonlight accompanied by a great variety of auroral displays. On 16th January at 10:00 am, I was puzzled by a red glow of great intensity on the southeastern horizon. By 11:30 the sky was aflame with red, orange and violet colors. This initially perplexing display finally convinced me that we would see the sun within a few days. Indeed, the sun first appeared for 15 minutes on 21st January.

In early January, prior to availability of the hot-water ice cutter, I usually chopped a hole (3-ft, or 1 m in diameter) through the ice with a pick and chisel and initiated a procedure to determine if I could keep a

large hole open for an extended period. Using an approach suggested by Jacob Stalker, who used this method to keep fishing holes open in waters adjacent to his home in Noatak, Alaska, I covered the hole with a plywood board, snow blocks and loose snow. The next day I uncovered the hole. The ice had frozen in a few inches (5 cm) on each side of the hole but only a thin veneer of ice crystals had formed on the water surface. Thus, it was possible to keep such holes open indefinitely if the sides were cut back daily with an ice chisel and the ice crystals scooped off the water surface. This was a very cold day (-32°F , or -37°C) for working on the ice, but it did not seem unpleasant since there was only a light wind. Nevertheless, when I returned to the laboratory I noted that my eyebrows, eyelashes and hat carried a thick layer of frost on them from my frozen breath. This frosty appearance was common on all subsequent winter days when we worked on the ice.

On 24th January we first successfully used the Huff ice cutter at the sampling station closest to shore. It was a relatively warm day with an air temperature of $+2.4^{\circ}\text{F}$ (-16°C). In previous trials of the cutter, we had mounted the cutter on sleds and pulled it with a weasel to the longshore ice ridge. We then had to man-haul the sleds and other gear over the ridge. Fortunately, by 24th January a roadway passable for a weasel was opened over the ridge, and we easily moved the cutter to the station site with a weasel. The ice-cutting operation was successful, and we opened a hole about 3 ft x 3 ft (1 m x 1 m) in about one half an hour. The hole was then covered with a board and snow, and kept open by chiseling away the ice edges every time I sampled there. Daily water samples were now easily collected, fish traps could be readily deployed and recovered everyday and plankton collections made more frequently.

We had previously been unconcerned about polar bears in the vicinity of our offshore activities but on the morning of 25th January a polar bear appeared some 500 yards (0.5 km) behind the NARL Camp. The bear was eventually shot by one of the Inuit men in the camp. Thereupon we decided to be more alert for the presence of bears. After that incident, Chester Lampe brought a rifle along whenever we ventured onto the ice. That day we (Chester, Hoover and myself) went out about one mile (1.6 km) to cut another hole in the ice. We used a weasel to pull the sled carrying the ice cutter. We had to walk beside the sled since it tended to tip over whenever it went over sloping or uneven ice, but two of us could easily prevent it from falling over. It was a relatively warm day with a temperature of $+16^{\circ}\text{F}$ (-9°C).

C) so that it was a pleasure to work on the ice. In fact, the exertion of the day made us sweat considerably under our jackets. We readily cut a hole, took four plankton samples to a depth of about 35 ft (11 m) and then covered the hole as we did with the inner hole the previous day. For the past month, prior to lowering and raising the plankton net, it was necessary to first scoop ice crystals from the water and pour hot water (heated on a Coleman Stove) into the ice hole. The hot water prevented the net from freezing as it emerged from the hole, and allowed water to drain out of the net. As soon as the flask containing water and plankton organisms reached the ice surface, it was immediately wrapped in thick insulating material so that organisms could be kept alive for observation in the laboratory. On this occasion and on other midwinter sampling trips I collected many planktonic organisms. These included polychaete, crustacean and molluscan larvae as well as ctenophores, medusae, some pelagic polychaetes (*Autolytus fallax*) with egg clusters and large numbers of copepods, some of which also had egg clusters. The following day we went out 1/2 mile (0.8 km) and opened another hole with the ice cutter. The procedure was now very efficient and only required 15 minutes to open the hole. We subsequently opened additional holes at various offshore locations, all of which we were covered with insulating material and snow to retard the rate of their re-freezing. Today while we were out on the ice we saw the entire sun for the first time as a red ball above the horizon.

Now that we had our ice holes protected by overlying insulating material, we proceeded to deploy various types of traps, baited with meat, chicken viscera or fish through the holes. On January 27 Chester, Hoover and I lowered a fish trap, made of chicken wire with lead-in cones at both ends, into the hole closest to shore. This and all other traps (with the one exception noted below) were always lowered to the bottom. Then we moved offshore and tried a new type of trap, a lath trap (similar to a lobster trap), at the hole 1/2 mile (800 m) offshore. We positioned this trap so that it floated under the ice, hoping that it would increase our ability to catch Arctic cod. We then walked out to the hole 1 mile (1.6 km) offshore and pulled a baited oil-drum trap deployed there the previous day. The trap contained at least three species of amphipod crustaceans, some of which were carrying eggs. It was dark by the time we returned to camp. Several days later, we pulled the traps at the three stations. The two inshore traps contained Arctic cod. Examination of stomach contents showed that the fish were feeding on amphipods. The trap at the outer station contained amphipods and a

small polychaete worm. The lath trap had only a few cod in it, and did not seem to improve our ability to catch fish.

Although air temperatures were low during late January, temperatures in early January hovered for a week around +15° to +20° F (-10° to -8° C). Chester Lampe said that in the 20 years he had lived at Barrow Village, he could not remember such high January temperatures. He mentioned that a man from the village had killed a seal during that period; the seal had been eating Arctic cod.

On 31st January, John Huff, Jacob Stalker, Chester Lampe, one other assistant, and I took the ice cutter to the station 1/2 mile out to enlarge the opening in the ice. No weasels were available so we had to man-haul it over the ice. It was a difficult trek because strong SW winds had built up snowdrifts that we had to cross. On the way we pulled the trap from the hole closest to shore and removed an Arctic cod that had been eating amphipods. The cutter successfully enlarged the holes at both stations. Today we used diesel fuel rather than gasoline to heat the circulating water, a change that reduced the chance of an accident when the fuel ignited. Several days earlier I received minor facial burns when I ignited the fuel, so I was very pleased with the change to diesel. My accident resulted in considerable laughter by my Iñupiat companions, individuals who had always been there to help me during so many risky activities over the months. Although initially puzzled by their apparent lack of concern, I ultimately recognized that accidents must be commonplace to people surviving in such a harsh environment. If their reaction to such events triggered melancholy or depression, their ability to survive might have been compromised. In my case, they showed concern for my condition shortly after a period of mirth. They all had a good laugh in subsequent days when my face appeared sunburned, as if I had been exposed to tropical sun.

By 2nd February winter had returned and temperatures of -21° F (-30° C) were recorded early in the day. For many previous days it had been cloudy, but today it was a beautiful, clear day with the sun visible for a short period; a beautiful sight to see after our long period of darkness. The sun remained low on the horizon and was still a red-orange color. The snow reflected this tint making the view in all directions a beautiful one. On this wondrous day, Hoover, John Huff and I went out to the station closest to shore (depth of 7 feet, or 2.2 m) to build a Quonset hut of snow blocks over the ice hole. John had made a wooden arch of plywood,

placed on a wooden box at both ends of the arch. We cut blocks of snow and placed them over the arch. We filled the chinks between the blocks with snow and poured water on the arch, which immediately cemented the blocks together. The arch was then moved back by removing the boxes and placing the wooden arch back on the boxes after they had moved the width of the snow blocks. We continued this procedure until we had a snow house 12 ft in length, 7 ft wide and 7 ft high (4 x 2.2 x 2.2 m). One end of the hut was a wall of snow blocks while the other end would eventually have a canvas and frame door inserted into a wall of snow blocks. While building the snow hut, I was working so hard that I did not feel the cold to any extent although the strong wind was discomforting. When the hut was finished, my eyebrows, eyelashes and mustache were frozen and I had plugs of ice in my nose. So, it was a pleasure to go into the completed hut and take water and plankton samples as well as deploy traps in relative comfort (Fig.12).

The next day the air temperature was -27°F (-33°C), and it was another clear, sunny day. We finished the



Fig. 12. Howard Feder outside one of the snow houses built over refrozen leads. Snow houses enabled samplers to work in relative comfort.

snow hut by inserting and stabilizing the canvas door. We could now work in the hut with our gloves off while taking water samples, pulling traps, using the plankton net and handling specimen bottles. The reduced light in the hut made it possible to see organisms floating in the ice hole. Ctenophores, accentuated by their blue-green luminescence, moved by rapidly, an indication of strong underice currents close to shore. Water temperature was still a consistent -2.0°C (28°F). The trap pulled that day contained an Arctic cod that had been feeding on amphipods. By the time we finished with our work that day the air temperature was -34°F (-37°C).

Several days later we lowered a battery operated light in a bottle through the hole located within the snow house to observe the bottom. The bottom was muddy sand. No animals were observed over a several day period. We also tried placing the light in the bottle in our traps to see if we would increase the number of animals in the traps; we saw no differences in the number of animals collected when the light was in the traps.

We ultimately decided to increase the air temperature in the snow houses while we worked by having a lighted Coleman lantern on the ice next to us. This made it easier on our hands when we pulled the fish traps. It was apparent that the most effective trap was the oil drum unit with two fine mesh lead-in cones, but its weight made it difficult to handle in the huts. So, we generally used the fish traps constructed of chicken wire. In early February we began catching up to six fish several times per day. The relative warmth in the hut made it possible to transfer the fish quickly into a container of water so they could be returned to the laboratory alive. The fish were maintained in the physiology laboratory at $+1.0^{\circ}\text{C}$ (34°F).

In early February on a clear, cold day with temperatures hovering at -24°F (-31°C) Chester Lampe and I walked out on the tundra. We went about two miles from the NARL camp looking for lemmings for one of the physiologists at the laboratory. Chester said to look for small holes in the snow. We ultimately found six small holes, each covered slightly with snow. Although we dug beneath the holes, we did not find nests. Fox tracks and fox droppings were observable throughout the area. We finally found one lemming nest, apparently uncovered by a fox but did not find any lemmings. On the way back, Chester told me that the sides of my nose were white. I immediately put the palm of my hand over my nose, which soon restored circulation. I had found that it was typical of any of the Inuit who worked outside with me during winter to

immediately tell any companion when it appeared that any portion of his face was becoming frost bitten (as noted by white spots on the skin). I was taught to immediately take off my glove and put my warm hand against the white spot. My companions would tell each other when the cold spot was returning to its normal color. My hands became very cold that day, and I realized that leather mittens and wool liners did not offer sufficient protection for long periods at such low temperatures. It was obvious that the Inuit skin gloves were the only ones satisfactory for long treks overland in winter.

Water supplied to our Quonset huts was pumped through a hole in the ice of a freshwater lake near the Arctic Contractor's camp and delivered in a large tank truck to each hut. One day in mid-February, while I was pouring a glass of water in my hut, a number of very active, bright red insect larvae entered my glass with the water (probably overwintering chironomid larvae from the lake). As a city dweller in the lower 48 states, I would have been horrified by this event, but somehow as a resident living in the crude hut in the arctic, it just seemed like another interesting event.

Air temperatures in mid-February were now frequently -25°F (-32°C) to as low as -35°F (-37°C) with the ever present wind increasing the chill factor. I finally decided that it was time to imitate the Inuit men and women by putting on a snow shirt (I had a black one and a beautiful powder blue one made for me by Mrs. Lampe) over my parka; this prevented the ever-present wind from penetrating the parka zipper and made it easier to work all day on the ice. On a clear 9th February, with an air temperature of -27.8°F (-33°C), we initiated a trip to establish a remote sampling station. Chester Lampe's son Frank used his team of seven dogs to pull our gear out. On the way we stopped at the nearshore snow hut and lowered a wire mesh fish trap. We crossed three pressure ridges as we progressed outward and encountered very rough ice and some new ice 2500 yards (2.5 km) from shore. Considerable pick and shovel work was necessary to make it possible for the sled to cross the pressure ridges. We saw many polar bear tracks along the way, some of them very large. In fact, a bear had pulled up one of the flagged stakes previously placed along the route. A recently frozen lead was present just beyond the last pressure ridge at approximately 3500 yards (3.5 km) from shore. We cut a hole in the thin ice with the Huff ice cutter, and built another snow house over the hole by the method described previously. We saw a number of Inuit hunters and their dog teams on the ice. We went out to the snow hut the next day to sample through the

hole. There were fresh polar bear tracks around the house. Hoover and I put out 13 more flags, one hundred yards apart, so that there were now marker flags out to 4500 yards (4.4 km). These and the markers we put up during our initial forays on the ice would enable us to find our way back to shore in the event of whiteout conditions. While we were working, we saw five hunters and their dog teams. Prior to returning to camp I took a plankton haul at the 3.5 km station.. Although it was now -35°F (-37°C), it was possible to melt ice crystals on the water surface and complete the haul by using hot water heated with a Coleman stove. At this temperature it was essential to cover the plankton sample rapidly with insulating material. The sample contained a few circular diatoms and large numbers of copepods.

Several days later, we pulled our gear out by dog team to a recently formed lead approximately 3.1 miles (5 km) from shore. We set up a tent at the site to periodically warm ourselves because air temperature were rarely above -25°F (-32°C) that the day. We were out there to try a new procedure designed to obtain benthic animals from the bottom with a dredge. Dredging was accomplished as follows. Two large holes were chopped in the ice approximately 350 ft (110 m) apart. Between the two large holes we chopped smaller holes at 15-ft (3-m) intervals and pulled a line from hole to hole under the ice using a grappling hook. The line at one hole was attached to a dredge that was lowered to the bottom while the other end was attached to the dog team. The procedure was a success, and benthic organisms representative of many phyla were collected. This dredging technique was deployed successfully on three other occasions in late February and early March at depths of 135, 149 and 162 ft (41, 45 and 49 m).

One day in late March we received word that a lead in the ice had opened in the general vicinity of one of our snow-house covered stations 2700 yards (2.7 km) from shore. Chester Lampe, the physical oceanographer Jack Wickham, Rodgers Hamilton (the ornithologist who had wintered at the camp with me) and I walked out to determine if our snow house and its contained gear had survived. The lead was about 1 mile (1.6 km) wide and extended in both directions as far as the eye could see. Our snow house had been built over a lead, and it was along that lead that the ice had cracked and moved offshore. The snow house had been used for physical oceanographic and biological sampling. One half of the snow house was gone (Fig. 13), taking a meter wheel, a winch with 200 ft (70 m) of steel cable and two fish traps with it. By using field glasses, we



Fig. 13. Half of a snow shelter on 23rd March 1950, after the lead over which it had been built opened, and carried off the other half of the shelter and some sampling gear. The location was approximately 2.5 km from shore, where water depth was about 25 m. The orange device in the author's hand is a bottom sampler. Photo, R. Hamilton.

sighted our marker flags and the other half of the snow house across the lead. I took a plankton sample along the ice edge and then sent down a small bottom sampler, which only brought up sticky mud. A number of Iñupiat with dog teams passed us on the ice; they had been hunting seals. One of the men appeared to be an albino (Fig. 14). He had one of the most beautiful sleds I had seen at Barrow and a handsome dog team to go with that sled. He had been out since early in the morning. His son came out to meet him, and took the sled out for further hunting activity while his father walked back to the village. Examination of the plankton sample in the laboratory showed diatoms, ctenophore larvae, polychaete larvae, crustacean larvae, molluscan veliger larvae and large numbers of copepods, some carrying eggs.



Fig. 14. Rodgers Hamilton, visiting Iñupiat hunter, and Howard Feder by the edge of the open lead on 23rd March 1950. Photo, R. Hamilton.

On Sunday 27th March with an air temperature of -29° F (-34° C) with light snow falling, Rodgers Hamilton and I decided to emulate Vilhjalmur Stefánsson, the arctic explorer. We followed the instructions included in his book "My Life with the Eskimo." We cut large snow blocks (the snow on the ice was compact and readily cut into blocks with a machete or other similar cutting tool), and began placing them in a circle. We spiraled our snow blocks around the circle, making certain that each block leaned back and keyed in with the previous block. We completed most of the igloo except the roof on this day. It was interesting to watch the young men from the village as they stared at our construction activity. None of them had ever observed an igloo since this was a structure used primarily by Inuit of the Canadian Arctic. We finished the igloo on the following Sunday. Virtually all of the snow blocks remained in place, but we could not get the last four or four blocks on the very top of the igloo to stay in place. Obviously the skill to finish the very top of the structure required experience, or some skill that we amateurs lacked. So we had to cheat by chopping a hole in an adjacent lead, scooping out sea water and sprinkling it on the snow blocks to freeze them in place (the Greenland Inuit people were highly skilled in the construction of igloos, and never needed water to hold the blocks in place). We finished our snow house by making a small tunnel leading out of the igloo, a standard procedure in igloo construction to isolate the inner region of the structure from external winds and blowing snow (Fig. 15). Although we did not sleep in the structure, we did spend time in it during subsequent days. We were always warm and comfortable inside but needed a Coleman lantern to see inside the structure. The Greenlandic Inuit were often able to resolve this problem during periods when it was light outside by



Fig. 15. Howard Feder emerging from the snow shelter the crew built on landfast ice, following Vilhjalmur Stefánsson's prescribed methods from the Canadian Arctic.

situating their igloos near a recently frozen lead. After they completed the main structure, they would cut out a section of ice from the lead and place it within one wall of the snow house to serve as a window.

By early April the roof of our snow house close to shore was beginning to sag as a result of warming weather and snow accumulation, and we found it necessary to knock down the ceilings of the house. When we went out to the station at 2700 yards (2.7 km) on 7th April, we found that the ice had moved once more so that the remaining portion of our snow Quonset hut was gone. In its place was a great mass of upheaved ice and the lead was frozen over. We walked over the ice and came to a narrow lead (4-5 ft wide) at approximately 3200 yards (3.2 km) from shore. We saw three men with their dog teams resting next to the lead. Two of their sleds had kayaks on them. We brushed away the surface ice on the lead and saw hundreds of small polychaete worms (the syllid *Autolytus*, most of which were carrying egg sacs) in the water. I had observed this polychaete in the water, in varying numbers, for several weeks in plankton samples. I collected a small sample of the polychaetes in the water for further examination in the laboratory. We chopped a road through the ice mass so that we could bring our weasel close to the lead later that day. A northeasterly wind of considerable force came up in the afternoon, and it was considered unwise to remain on the ice. During the next few days the wind abated, and Hoover and I again drove to the lead 3200 yards (3.2 km) out to make a plankton haul. The ice had not moved and the lead was still present, although it was now covered with about 2 inches (5 cm) of ice. There was a crack in the ice wide enough to insert the plankton net. We set up a stove in a semi-sheltered spot behind an ice block, put up a wind break and lowered the net through the opening in the ice. *Autolytus* was present. Hoover and Chester Lampe said that the presence of so many of these worms in the water usually meant there would be a good whaling season. Copepods were also abundant in the sample. The sky was very dark to the west today, and a rumbling sound could be heard coming from that direction. Hoover and Chester said that this was the sound of heavy surf against the ice edge.

On 11th April Pete Sovalik and I drove our weasel to the ice mass in the vicinity of the 2700-yard (2.7 km) station. We then walked out to a lead about 1.5 miles (2.4 km) farther out from the station area. We carried considerable gear with us: 8 flags, pick, ice chisel, 200 ft (of line, a small bottom sampler, half a dozen bottles and a rifle. The width of the lead varied from 50 to 400

yards (50 to 400 m) wide. Our task for the day was to sample along the lead as far as we could to determine the type of bottom substrate present offshore. We dropped the sampler from the ice edge every 100 yards (30 m). As we walked, we found cracks in the ice with up to 3 inches (8 cm) of soft ice in them. We ended our bottom-testing survey opposite the south end of Barrow village at approximately 2.5 miles (4 km) from shore. All but one sample yielded a sticky mud. The one exception had a sandy mud-gravel-shell composition and was the only one with animals present. The sample contained a few small polychaetes, clamshells of *Hiattella* and live *Macoma* sp.

At our various stations in April a variety of traps were deployed through holes in the ice for one to several days. By mid-April, the ice over the leads where we maintained holes for trap insertion was five feet (1.5 m) thick. All holes were covered with insulation between sampling periods to reduce freezing. It was now light 24 hours a day. Various snails (mainly *Buccinum* spp.), amphipods and a few Arctic cod were recovered from the traps. It was apparent that the traps were not very efficient since people from the village caught fish in great numbers through ice holes. Each person would lower a line with a small amphipod-like object (generally made out of a piece of copper) and a hook at the end. The line would go down 30-40 ft (9-12 m) and they would continually jerk the line up and down. Chester said his wife caught three gunnysacks full of Arctic cod the previous day. Despite the poor catch rate of our traps (Fig. 16), this was the only method that enabled us to collect fish without injuring them and bring unfrozen, live fish to the physiology laboratory.

By 21st April the men from Barrow had set up five whaling stations along the wide lead about 2.5 miles (4 km) from shore. Whales had been sighted from the



Fig. 16. Pete Sovalik and the baited trap used for obtaining Arctic cod for the physiological laboratory.

stations but all were too far away to pursue in their *umiaks*. By 24th April, the lead adjacent to the whaling stations was estimated to be 20 miles (32 km) wide. We took a plankton haul at our outer station on this day. The air temperature was about +5° F (-15° C) but the wind chill was extreme as a result of a strong northeasterly wind. We nevertheless accomplished our work without shelter, by using our weasel as a windbreak. We used buckets of hot water, heated by our Coleman stove, to keep the water in the hole free of ice crystals. This procedure prevented the samples and net from freezing as it was raised. The samples were immediately put in thermos jugs and wrapped with insulating material. On this day I was wearing shoepacks since my felt shoes had torn. This was the first time my feet felt cold out on the ice since the previous autumn when I wore shoepacks. The felt boots are obviously as useful as 'mukluks' for surviving in cold weather conditions while shoe packs used by military troops were dangerously inferior. In fact, many soldiers had their feet frozen in winter during the Korean War when they wore shoepacks. An examination of the plankton sample in the laboratory showed a few diatoms, some hydromedusae, polychaete and molluscan larvae, many copepod larvae and adults.

The relatively warm weather at the end of April with temperatures well above 0° F (> -18° C) made it easier for us to accomplish the daily activity of water sampling and trap recovery. On one day when we pulled a bottom trap closest to shore (at a water depth of 37 ft, or 11.3 m) we found two eel pouts (*Lycodes* sp) that were 31 and 29 cm (12.5 and 11.8 cm) long.

By 27th April, snow buntings (*Plectrophenax nivalis*) were common around the Camp, and we could hear them throughout the day. Large flocks of eider ducks, often numbering in the thousands of birds, could now be seen over the ice. The first small flocks of these birds had been reported several days earlier.

On 29th April, an overcast day with an air temperature of +23.4°F (-5°C), the first Bowhead whale (*Balaena mysticetus*) was killed at the camp 3 miles offshore. When I walked out to the camp in the afternoon, the whale was still in the water at the ice edge. Open water extended to the horizon. The whaling crew tied a line to the tail region of the whale and pulled the whale on the ice using a block and tackle. Over 100 men pulled on the line. The line broke a few times before the whale was finally on the ice. It was approximately 26 feet (8 m) in length. The women cut some of the skin and blubber (*muktuk*) off the whale and offered it to the people standing around. The black skin portion of the

raw *muktuk* was rather tough with a nutty flavor but the raw blubber was tasteless. The skin tended to become wedged between one's teeth. About 350 people from the village, numerous dog teams and some scientists from NARL visited the camp. There was considerable yelling and laughing as well as crying and barking of the numerous dogs present (Fig. 17). A number of men cut up the whale and loaded the meat on sleds. The muscle was almost black and very soft and gelatinous in consistency. When they cut into the heart and aorta, blood spurted out like water from a fire hydrant. Many of the older women picked up the coagulated blood and put it into bags. I was told this would be used to feed dogs. By 7:30 in the evening most of the whale had been cut up and taken away. The entire loading procedure appeared well organized, although it was not clear to me how the meat had been divided among the many people present. Another larger whale (46 feet, or 14 m long) was killed the same evening. This whale had to be cut up in the water as it was too heavy to pull on to the ice. It took the whaling group until 3:00 AM to finish butchering and distributing that whale.



Fig. 17. The whaling captain slides down the first bowhead whale caught in 1950, about 3 km off the coast on 29th April.

Several days later another whale was killed at another whaling camp. This one was 30 feet (9 m) in length. When I arrived in the late afternoon, most of the whale had been cut up and moved to the village. I was told that when the first whale had been killed and cut up, the women had become so excited that they took more than their share. Consequently, the hunters did not get the amount of whale meat that was traditionally allotted to them. This time the women were kept back from the whale until the hunters obtained their share of the meat. Consequently, when a "free for all" was declared, not very much was left except blubber, meat scraps and bone. The women nevertheless dived in shouting, laughing and cutting away wildly with their *ulu* knives. I was amazed that no one was injured but all seemed to

go well. They pulled chunks of meat and blubber from the whale carcass, and threw them into gunnysacks. They continued this activity, even dragging off the bones, until nothing was left except a bloody spot on the ice. While all this was going on, some of the women were cooking *muktuk* for all to sample. The black skin still had a nutty flavor but the cooked blubber was delicious with a sweet, oily taste.

May was my last month in the Arctic. Each day became warmer until the air temperature remained above freezing most of the time. It was now possible to sample every day without concern about frozen fingers (Fig. 18). The plankton hauls during this month always contained large numbers of a variety of larvae and adult zooplankters. The traps deployed through holes in the ice were now catching Arctic cod and eel pouts as well as polychaetes, many amphipods and the snail *Buccinum*. On 8th May a small whale (25 ft, or 7.6 m) was killed at the camp near the village. This whale only took 3 hours to cut up and allocate to the waiting sleds.

In early May my friend, the ornithologist Rodgers



Fig. 18. Pete Sovalik enjoying spring warmth, May 1950.

Hamilton (Fig. 14), who had overwintered with me at NARL, asked if I wanted to fly to Barter Island with him. Work in the laboratory and field prevented my accompanying him. On 9th May at 2:00 PM Hamilton's plane left Tigvariak Island (near Barter Island) and was reported missing shortly afterward. The Tenth Rescue Squadron out of Fairbanks carried out a search for the plane with two C-47 aircraft, a C-4 and a B-17. No one could understand what had happened since the pilot (Galbraith) had an excellent safety record with 10,000 hours flying time including flights over Burma during WW II and participation in the Berlin Airlift. The search was pursued for over three weeks, but no trace of the plane was ever found.

On 6th May, the ice mass that had been thrust onshore 26th December was pushed by "Cats" back out onto the sea ice. This was necessary so it would go out to sea when the rest of the ice moved offshore in summer. Clearing the beach of ice was necessary to allow supplies to be unloaded from landing barges when the annual supply ship arrived. After the tractors pushed ice from the beach onto the nearshore ice, the whole mass began to buckle and melt rapidly along the shore. Consequently, I often fell through the ice into about 1 1/2 ft (0.5 m) of water when I went out to check my traps and take plankton hauls. As the month progressed, it became more and more difficult to cross to safe ice. By 18th May there were only a few spots that I could use to cross from the shore to ice safe enough to walk on.

By mid-May most of the snow within the Camp had melted. The streets were wet, with large puddles that made walking more difficult than during the season of snow-covered streets (Fig. 19). It rained for the first time this year on 11th May. On 17th May, when I went out on the ice to sample, I saw my first gull of the year flying over the ice at Point Barrow. I no longer had to heat water when sampling plankton. Ice crystals did not form on the surface, and my net did not freeze when it emerged from the water. The oceanographer, Jack Wickham, was now able to deploy his Nansen bottle and bathythermograph into the ice hole without setting up a tent.



Fig. 19. Breakup and puddles as seen looking NE down the main street in Camp, 25th May 1950.

On 18th May, a whale that had been killed several weeks ago floated up beneath the ice. It had sunk after being struck by the whaling crew. The men from the village intended to use dynamite to break up the ice in order to retrieve the whale.

Also in mid-May, I walked out to the offshore snow houses. The roofs had collapsed (Fig. 20), but the front and rear walls and the lower part of the arches were still standing. These structures had served us well during the coldest months. They withstood strong winds but finally disintegrated as air temperatures climbed above freezing. It was novel to sample through the holes within the remaining snow-house structure without concern about freezing my hands. Several trips were made out to an ice hole 3000 yards (3 km) offshore to make plankton hauls and pull fish traps. Each day increasing numbers of Point Barrow gulls and eider ducks were observed. The ice was now so thin on leads that it became easy to chop a hole to make plankton hauls.



Fig. 20. Reidar Wennesland standing by one of the collapsed snow shelters used for sampling on Chukchi Sea landfast ice, 21st May 1950.

I made my last trip onto the ice on 30th May (Fig. 21). Sea ice was melting chaotically all along the shore wherever heavy equipment operators had pushed override ice off the beach. Despite my risking slips or falls into pools of water around the deformed nearshore ice, the plankton haul that I made that day contained the greatest abundance of organisms that I had observed to date. Larvae of ctenophores, polychaetes, crustaceans and mollusks were common or abundant, and larvae of several other phyla were also present. Adult copepods were extremely abundant. This was a wonderful way to end a series of collections that had begun almost one year previously.

The next day I sadly turned in the arctic gear that had served me well during the extreme conditions often encountered during my many trips along the shore in late summer and early fall, on the sea in Professor MacGinitie's small vessel (the *Ivik*) and on the sea ice. As the airplane left the airstrip, I first looked out upon



Fig. 21. Howard Feder inspecting a beluga whale fetus, 30th May 1950, on final day of fieldwork at Barrow. Photo, R. F. Black.

the vast expanse of sea ice where I had spent so many exciting days, then gazed down at the tundra where I had wandered for short periods of time. I found myself wondering how I would cope with the crowded, chaotic conditions of the towns and cities of the lower 48.

SPECULATIONS ON A FEW UNSOLVED MYSTERIES

The investigations of Chukchi and Beaufort Sea marine environments adjacent to the Barrow area from 1948-1950 by MacGinitie (1955) opened a window on the types and distributions of benthic species present and their reproductive habits. Professor MacGinitie envisioned that his initial natural history studies would naturally lead to long-term investigations of the benthos, combining field and laboratory studies. His vision for continuity of benthic work by investigators at NARL did not materialize in subsequent years. A NOAA-OCSEAP-funded benthic survey by Carey *et al.* (1984) sampled a limited number of stations adjacent to Point Barrow for infaunal invertebrates in the mid-1970s, but the major thrust of that more recent work was in the western Beaufort Sea. Consequently, some questions raised by MacGinitie's (1955) monograph remain unresolved. Several of his observations have assumed greater significance in light of findings by subsequent investigations, the objectives and geographic emphases of which have varied greatly. MacGinitie (1955) described an offshore "rubble zone, consisting of pebbles...to boulders that may weigh tons. This rubble is ice borne and ...rather spotty." The location of this type of bottom is uncertain, because MacGinitie's monograph specifies only the depths at which he encountered this formation, but neither distances nor bearings from known points onshore.

Mohr *et al.* (1957) noted: "Probably no other feature of the marine biota of the Point Barrow area is more

striking than the absence of macroscopic benthic...[algae]." Kelp and small species of benthic macroalgae were absent from the beach and offshore collections of G. E. MacGinitie. In the context of Dr. John Mohr's observations, my notes record that on rare occasions following storms, I observed fragments of badly decayed kelp on the beach, and on a single occasion a windrow of "algal material" on the shore (unpubl. notes: Feder). Several years later, Mohr *et al.* (1957) also reported finding occasional stranded pieces of kelp on beaches in the area after storms but never noted conspicuous masses (windrows) of macroalgae on the strand line. No algae were collected by dredge from many offshore stations occupied by the LCM *William E. Ripley* off Barrow from 1951 to 1954 (Mohr *et al.*, 1957). Nevertheless, discovery of a few scattered kelp beds approximately 80 km southwest of Point Barrow on a rocky bottom reminded us that limited presence of these marine plants might be expected in the Chukchi Sea if an appropriate substrate were available (Mohr *et al.*, 1957). Dunton *et al.* (1982) documented the occasional presence of pieces of algae as drift on beaches of the adjacent Beaufort Sea from Point Barrow to the Canadian border. Early work to assess the substrate of the Beaufort Sea from western arctic Alaska to the MacKenzie Delta in the east reported a bottom composed of fine sediments without large regions of rocks or boulders (Carsola, 1952). Since a rocky substrate is required for attachment and survival of algal species, it was long assumed that algal beds would be rare. In 1971, Dr. Erk Reimnitz discovered abundant kelp (predominantly *Laminaria solidungula*) and a diverse invertebrate fauna attached to cobbles and boulders (now termed the "Boulder Patch") near Prudhoe Bay in Stefansson Sound in the Beaufort Sea. That discovery and subsequent investigations during and following OCSEAP confirmed that a rich flora and fauna does indeed develop where a suitable substrate is available (Dunton *et al.*, 1982).

D. W. Norton's (pers. comm.) collection of living macroalgae from the beach between Barrow and Point Barrow included plentiful specimens of fresh *Laminaria saccharina* and *L. solidungula* after fall storms in 1993, 1995, and 1997. A substrate suitable for algal recruitment and growth therefore must have remained available somewhere near Barrow for a number of years subsequent to the late 1940s.

MacGinitie's offshore dredging activities adjacent to Barrow in the summers of 1948 and 1949 also collected epifaunal animals on gravel, rocks and occasional boulders that could also potentially serve as substrate for macroalgal communities. But in years when the

pack ice remains well offshore until late in the year (as occurred in the Barrow region in late September–October 1949), storms can erode the shore, and stir up large quantities of mud from the sea bottom and the shallow Elson Lagoon adjacent to Point Barrow (strong currents carry mud out of the Lagoon through Eluitkak Pass). Mud and vast amounts of tundra vegetation are carried out to sea, are spread along the Chukchi coast by strong currents, and eventually settle to the bottom. The storms of 1949 resulted in deposition of up to 4 inches (10 cm) of mud and tundra debris on the bottom out to at least 30 km (the limit of safe operations by the *Ivik*). Mud blanketed the areas previously dredged in the summers of 1948 and 1949 (MacGinitie, 1955: 56). Consequently, in the winter and summer of 1950 the formerly common epifaunal organisms were absent or uncommon in the muddy material collected by dredge (MacGinitie, 1955: 10, 56, 57). The periodic churning of bottom sediments and deposition of mud and tundra material on the sea floor indicate forces that would preclude the establishment of kelp beds. Such episodic disturbances of the sea bottom presumably make the benthic environment off Barrow a poor substrate for recruitment and survival of all benthic species. Dayton (1990) and Jewett *et al.* (1999) review literature that demonstrates that the benthic environment of shallow-water Arctic regions is subject to diverse natural disturbances. In such regions, storms in ice-free months are common, resulting in significant disturbance to benthic fauna through burial or excavation. On the other hand, we should not overlook the potential for strong bottom currents to serve as agents of floral and faunal dispersal, by moving organisms by bedload transport (Jewett *et al.*, 1999; Hall, 1994).

Faunal changes in the Barrow region have apparently paralleled floral changes. MacGinitie found only a single valve of the mussel *Mytilus* by dredge and none on the beach. By contrast with the absence of *Mytilus* in the Barrow region from 1948–1950, tens to hundreds of live mussels of all sizes were thrown onto the beach during autumn storms in 1993, 1995 and 1997 (D. W. Norton, pers. comm.). Several species of fresh macroalgae (kelp, predominantly *Laminaria saccharina*) were attached to most of the mussel shells (Fig. 22). The contrasts between 1948–50 and the mid-1990s strengthen my assessment that an extended period of stable conditions on a bottom suitable for recruitment and growth of the bivalve (as well as the algae) must have occurred since the early 1950s.

Although *Mytilus* is a widely distributed mollusk common in Icelandic and Greenlandic waters (Madsen, 1949; Petersen, 1978) and in the Canadian Arctic



Fig. 22. Mussels (*Mytilus*, sp.) and dried remains of attached algae that washed ashore as living specimens in fall storms in 1993, 1995, and 1997 between Barrow and Point Barrow. Specimens at left show attached *Laminaria solidungula* remains, while specimens at far right show *L. saccharina* remains. Annuli in valves indicate relatively slow growth. Drill holes in *Mytilus* valves made by predatory snails (probably *Polinices*) further suggest that long-lived subtidal populations of mussels near Barrow serve as a stable food resource for these predators. Photo, D. W. Norton.

westward to the MacKenzie River delta (Lubinsky, 1980), recent collections at Barrow are geographically anomalous: 1) *Mytilus* is not described from a large number of Beaufort Sea grab and otter trawl samples taken by Dr. A. G. Carey (Carey *et al.*, 1974; Bernard, 1974); 2) *Mytilus* was not observed or collected within the Stefansson Sound Boulder Patch in the Beaufort Sea from thousands of samples taken there (Dunton *et al.*, 1982; Dunton, pers. comm.); 3) *Mytilus* was not taken in any of 48 trawl stations occupied on the northeastern Chukchi shelf at depths of 18-50 m from Point Hope to Point Franklin (Feder *et al.*, 1994a; 1994b); 4) although *Mytilus* is described from the southeastern Chukchi and Bering Seas (N. Foster, pers. comm.) and from the Mackenzie River Delta, these localities lie many hundreds of km to the southwest and east of Barrow, respectively.

Mytilus grows slowly in subarctic and arctic conditions (Theisen, 1973; Blanchard and Feder, 2000), and planktonic larvae remain dispersive for relatively long periods in cold water (see discussion of settlement and recruitment by mussels in Gosling, 1992). Thus, currents bearing planktonic larvae from distant undisturbed beds could have furnished the founder organisms for mussel beds closer to Barrow. A possible mechanism for natural establishment of mussel beds is suggested by Feder and Bryson-Schwafel's (1988) observations on the development of mussel populations in Port Valdez, Prince William Sound, Alaska. The Alaska Earthquake of 1964 swept some shores and embayments

in Prince William Sound clean of mussels. Subsequently, pebbles and small rocks were transported onto barren mudflats by currents that lifted and moved macroalgae and the rocks to which the algae had fastened themselves. When aggregations of small rocks and pebbles reached a certain density, the barren mudflats were transformed into suitable substrates for attachment by mussels and the development of mussel beds. A similar mechanism in the presence of strong currents in deeper waters could account for colonization, or recolonization of disturbed areas in the Arctic.

An alternative explanation for previously unsuspected mussel beds near Barrow is that hulls or ballast water of ships passing Barrow may have introduced founder populations of *Mytilus* (e.g., see discussions in Carlton, 1985, 1992). However they were established, it appears likely that there are undiscovered mussel beds, perhaps in the vicinity of the Barrow Canyon, from which occasional strong currents dislodge algae, rocks, and mollusks in a manner similar to that described above for Prince William Sound. The effects of sea ice on the benthos on the Northeastern Chukchi Sea shelf are less intensive and pervasive than those on the shallow shelf along the Beaufort Sea (Feder *et al.*, 1994a; 1994b). Reduced ice gouging on the bottom adjacent to the Barrow Canyon could result in conditions that support mussel populations. Pinpointing local origins of the *Laminaria* and adult *Mytilus* illustrated in Fig. 22 would probably help explain the persistence of a benthic community at depths where 1) light penetration is sufficient for algal primary production, but 2) bottom disturbance, as from ice gouging, is suitably infrequent to have allowed maturation by benthic fauna. We might also be able better to judge whether Professor MacGinitie's sampling effort just happened not to encounter then-existing *Mytilus* populations, or whether there has been a genuine change in northern Chukchi Sea benthos since the late 1940s.

Recent experiences with the priapulid "worm" *Halicryptus* further illustrate how changing physical conditions in the marine environment affect fauna of the Barrow region. This worm was collected both alongshore and by dredging in September 1949 but was not found in 1950 after the sea bottom was covered with mud. The systematics of priapulids and the genus *Halicryptus* intrigued Drs. Robert Higgins of the Smithsonian Institution, Tom Shirley of the University of Alaska's Juneau campus, and Volker Storch of the University of Heidelberg. This group appealed to residents of Barrow in the 1980s for help in obtaining the first fresh *Halicryptus* specimens since our 1949 collections. They prepared and circulated an

illustrated “wanted poster,” which offered to subsidize a successful search. No specimens were observed or collected for a number of years despite Barrow-residents’ regular searches of the beach following autumn storms. Then, in 1993, September storms brought ashore dozens of live *Halicryptus* along a 400-m stretch of shoreline just NE of “Duck Camp” (*Piguniq*). The specimens obtained were described as a species new to science, *Halicryptus higginsii* (Shirley and Storch, 1999; Storch *et al.*, 1999). The several unrewarded years of searching, followed by the spotty concentration of specimens that eventually did wash ashore, suggest variable recruitment and survival for this species, similar to the cases of *Laminaria* and *Mytilus*, above.

OUTLOOK

The Chukchi Sea region adjacent to Barrow is unique, presenting conditions for benthic organisms that differ from those in the adjacent Beaufort Sea to the east of Point Barrow. Understanding the physical, chemical and biological systems at the confluence of Chukchi and Beaufort Seas is essential if the contrasting marine systems of these seas are to be understood. Additional work at NARL can build on the framework of the early marine studies of G. E. MacGinitie, as Mohr (1969) suggested. Other contributors to this volume (Alexander; Weingartner and George; Weeks) argue for continuing the resurgence of various branches of arctic marine research based at UIC-NARL. The intensive interdisciplinary and international oceanographic studies underway in the Northeast Water polynya off Greenland could serve as a model for an approach to refining our understanding of the oceanographic features of the Beaufort and Chukchi Seas (e.g., Hobson *et al.*, 1995; Piepenburg *et al.*, 1997; Weslawski *et al.*, 1997). Expanding and upgrading of facilities to study the marine system in the waters adjacent to NARL would contribute to our understanding of the marine organisms in the offshore waters. UIC-NARL’s strategic position for hosting future research would be enhanced by the availability of a flow-through marine aquarium system, a well-equipped ice-strengthened research vessel for use in the open-water season, and equipment to support winter studies on the ice-covered sea.

The events recounted above were gleaned from a diary maintained during my stay at NARL many years ago, which miraculously remained in my possession during the intervening years. I am indebted to Professor and Mrs. G. E. MacGinitie for making my experience at NARL possible. The logistic support of the Arctic Contractors at Barrow Base made it possible to live

and work under the stressful conditions always present in the Arctic. The friendship, knowledge and capabilities of the four Iñupiat men who accompanied me on the many ice excursions and boat trips during the year were then, and still are, deeply appreciated. These men—Chester Lampe, Pete Sovalik and Hoover Koonaluk of Barrow, and Jacob Stalker of Noatak—were responsible for my survival under conditions totally alien to an urban person transplanted from southern California to Barrow. They also made it possible to accomplish the many tasks and ice and water excursions with relative ease and safety. I will always marvel at the skills of these men and their abilities to distinguish safe from dangerous situations that enabled them to survive and work in the harsh conditions of arctic Alaska.

My arctic year had been an extraordinary one in which I interacted with and survived this unforgiving environment in pursuit of marine organisms in the waters adjacent to NARL. Professor G. E. MacGinitie (Fig. 23), the second Director of NARL, for whom the sample-processing and taxonomic work was meticulously organized by Mrs. Nettie MacGinitie, orchestrated all the research activities. Professor MacGinitie was a multifaceted person with administrative skills and expertise in collecting, maintaining, and experimenting on live marine organisms. Many of his research activities prior to his administrative and research post at NARL are published in peer-reviewed literature and in a book on marine organisms (MacGinitie and MacGinitie, 1949). The previous research work and knowledge of the marine environment by the MacGinities contributed greatly to our understanding of the benthic organisms in the waters adjacent to Barrow. Prior to his work as a marine scientist, he had spent many years skippering coastal vessels. The skills he acquired made it possible for him to navigate and collect from the small wooden boat, the *Ivik*, in the hazardous waters off the Barrow coast for three successive summers (1948-1950). The *Ivik* had neither radio nor fathometer, and magnetic compasses were unreliable in the Barrow area. Compared with today’s navigational support by Loran, or Global Positioning Systems (GPS), Professor MacGinitie and his Iñupiat assistants could only apply skills learned during a lifetime of boat operation. He, Chester Lampe and Max Adams always managed to bring the boat safely to shore even under severe (i.e., zero-visibility) conditions. On several occasions when we were many miles offshore with virtually no visibility, Professor MacGinitie and Chester Lampe returned the boat to shore within a mile of the NARL Camp. They navigated by estimating the position of the boat from the bright spot in the ice fog that indicated the position of the sun, the time of day, the speed of the boat and the probable location of the NARL camp.

One of the major findings during MacGinitie’s many trips offshore in the summer of 1949 was his discovery of Barrow Canyon (Britton, *Foreword*, this volume: Fig. 1; Weingartner and George, this volume: Fig. 1), a finding of obvious significance to subsequent oceanographic work in the region. In my experience, investigators today remain largely unaware that Prof. MacGinitie should be credited for identifying this canyon. Professor MacGinitie was a modest man, not given to bragging of such accomplishments. MacGinitie was also a fine machinist, who with the assistance of the skillful and innovative laboratory machinist, John Huff, developed a functional device for melting holes for scientific sampling through sea ice at any time of the arctic winter. This device was important to scientists at NARL before gasoline-powered drills became available. I was privileged to assist Professor and Mrs. MacGinitie as they

assembled the first major collection of benthic organisms off the Barrow coast. They recorded details about the annual zooplankton cycle and reproductive activities of many of the animals there. Details of their collection and activities at NARL are included in MacGinitie (1955) and MacGinitie (1959). Most of their collection is housed in the U. S. National Museum at the Smithsonian Institution, and remains the single most important source of specimen-based information about the marine fauna for the Barrow region. I shall always be proud of my small role in the collection of much of that material during my year at NARL, and fondly remember the great adventures that accompanied the collection activities during my year in the Arctic.

Editor's Note: Although the author never returned to Barrow to collect samples, he came close while sampling benthic fauna in the northeastern Chukchi Sea from large vessels nearly four decades after the early experiences recounted here. In the late 1980s, he obtained benthic samples using a van Veen grab and large otter trawl (Feder et al., 1994a; 1994b). This sampling was considerably less laborious than cutting holes in the ice to prepare dredge and cable for pulling by dog team—an arduous process that MacGinitie (1955: 55) and the author used and illustrated.

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Fig. 22. Prof. George MacGinitie, second resident Scientific Director of the Laboratory, shown with a young captive wolf in October 1949.

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APPENDIX

The Naval Arctic Research Laboratory was a busy place during the year that I worked there. I believe that for context, it is appropriate to append here the names of the investigators present during that period and the titles of their projects. Some of these projects continued in subsequent years. Most of the investigators became my friends, and I was generally fortunate enough to be kept abreast of their activities. On several occasions I was able to assist them in their work. Most investigators gave talks to camp personnel at NARL to explain what their research entailed and to share preliminary results. Consequently, when my year at NARL was completed, I wound up with educational experiences touching on many scientific disciplines.

- Dr. R. F. Black and Hernelda Black. Investigation of ground ice. U. S. Geological Survey
- Dr. G. R. MacCarthy and Elizabeth E. MacCarthy. Permafrost investigations. U. S. Geological Survey
- Dr. J. B. Wickham, Janet W. Wickham and G. Groves. Oceanographic currents, sea surface-atmospheric relations. Scripps Institution of Oceanography
- L. D. Hoadley and D. M. Owen. Ice oceanography. Woods Hole Oceanographic Institution.
- G. S. Scholl and W. E. Austin. Studies of the earth's magnetic field. U. S. Navy Ordinance Laboratory
- Drs. X. J. Musacchia, L. A. Susca and B. J. Sullivan. Lipids and fats of arctic marine invertebrates and mammals. Work with hibernating arctic ground squirrels St. Louis University
- Dr. B. J. Sullivan and Joseph Mullen. Metabolism of arctic animals.

Boston College

Dr. Reidar Wennesland and Klaus Odenheimer. Tissue metabolism of Arctic cod adapted to Various levels of temperature. Stanford University.

Dr. I. L. Wiggins, H. J. Thompson and J. H. Thomas. Ecological and taxonomic Investigation of the vascular plants in the vicinity of Point Barrow. Stanford University

R.. N. Rowray. Snow insulation and its effect on sea-ice growth. Naval

Electronics Laboratory

Dr. N. Weber. Collection and identification of arctic insects. Swarthmore College

R. Hamilton. Birds and mammals of the arctic.

Dr. V. Walters. Freshwater fishes of the arctic. Swarthmore College

Dr. G. Llano. A survey of cryptogamic plants with emphasis on lichens. Smithsonian Institution

Fifty Years of Monitoring Geophysical Data At Barrow, Alaska

Jack Townshend¹

ABSTRACT: Continuity of observations, vital to understanding geophysical change, is exemplified by continued commitment of various government agencies, universities, and scientists to the research at the Barrow Magnetic Observatory, which is entering its second half-century of operations working cooperatively with its neighbors: National Oceanic and Atmospheric Administration Climatic Monitoring and Diagnostics Laboratory (NOAA/CMDL); Department of Energy, Atmospheric Radiation Measurement (DOE/ARM); Barrow Arctic Science Consortium (BASC); and the Barrow Environmental Observatory (BEO).

Key Words: U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), University of Alaska, U.S. Coast and Geodetic Survey (USC&GS), Environmental Science Service Administration (ESSA), Office of Naval Research (ONR), Naval Arctic Research Laboratory (NARL), Distant Early Warning System (DEW), Alaska Tsunami Warning Center Network, Browerville, geomagnetism, seismology.

The Barrow Magnetic Observatory (Fig. 1) is located on 101 acres of tundra at latitude 71.32° N, 156.62° W on the northern tip of Alaska, about 500 miles (804 km) north of Fairbanks and about 200 miles (322 km) west of Prudhoe Bay, site of the much-publicized North Slope oil fields.

The Barrow Magnetic Observatory is the northernmost of the U.S. Geological Survey's (USGS) 13 continuously recording, digital magnetic observatories. As such, it serves as a singularly important site in a global network of observing stations whose combined data define the planetary magnetic field and track the field's secular change. Ground stations such as the Barrow Observatory are controls for field modeling by harmonic analysis, essential reference stations for airborne and satellite surveys, and absolute calibration locations for field survey instrumentation. Data from Barrow are forwarded electronically to the USGS office in Golden, Colorado. From here, the data are distributed worldwide by the Central Region Geologic Hazards Team, Geomagnetism Group and sent to the international INTERMAGNET organization. Final processed data from Barrow and the other 12 USGS observatories are sent to NOAA World Data Center A for archiving and further distribution.

The hostile polar environment provides a major challenge in maintaining and operating the observatory. Temperatures remain below the freezing point most of the year, and the tundra-covered terrain consists of silt, sand, and gravel that has an active (seasonal freezing thawing) layer 2-4 feet (0.6-1.2 m) deep. Permanently

frozen soil (permafrost) lies below the active layer and extends to 1,330 feet (405 m). The general ground elevation at the observatory site is 8 feet (2.5 m) above sea level. The annual mean precipitation is less than 5 inches (120 mm); the mean annual snowfall is less than 30 inches (750 mm); and the mean wind speed is greater than 10 miles per hour (16 kmh) with extreme winds near 50 miles per hour (80 kmh) most months.

For more than half a century, scientists from four different federal and state government agencies [U.S. Coast and Geodetic Survey (USC&GS), Environmental Science Service Administration (ESSA), National Oceanic & Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS) and the University of Alaska] have prevailed and have operated the Barrow Magnetic Observatory under difficult and challenging conditions. In addition to the hostile climate, transportation, poor road and tundra conditions, and the threat of polar bears present daily challenges. All of the dedicated scientists involved in operation of this observatory are to be applauded.

Soon after the establishment of the Naval Arctic Research Laboratory (NARL) by the Office of Naval Research (ONR) in 1947, a dialogue began between the Geomagnetism Division of the USC&GS and ONR in Washington, D.C. about building and operating a magnetic observatory on the Naval Petroleum Reserve property controlled by the NARL. Agreements were reached between ONR and USC&GS and construction was started in 1948. The first facilities for the magnetic observatory consisted of a magnetometer absolute building to measure absolute values of the magnetic field and a magnetograph building to measure variations of the magnetic field. They were constructed about

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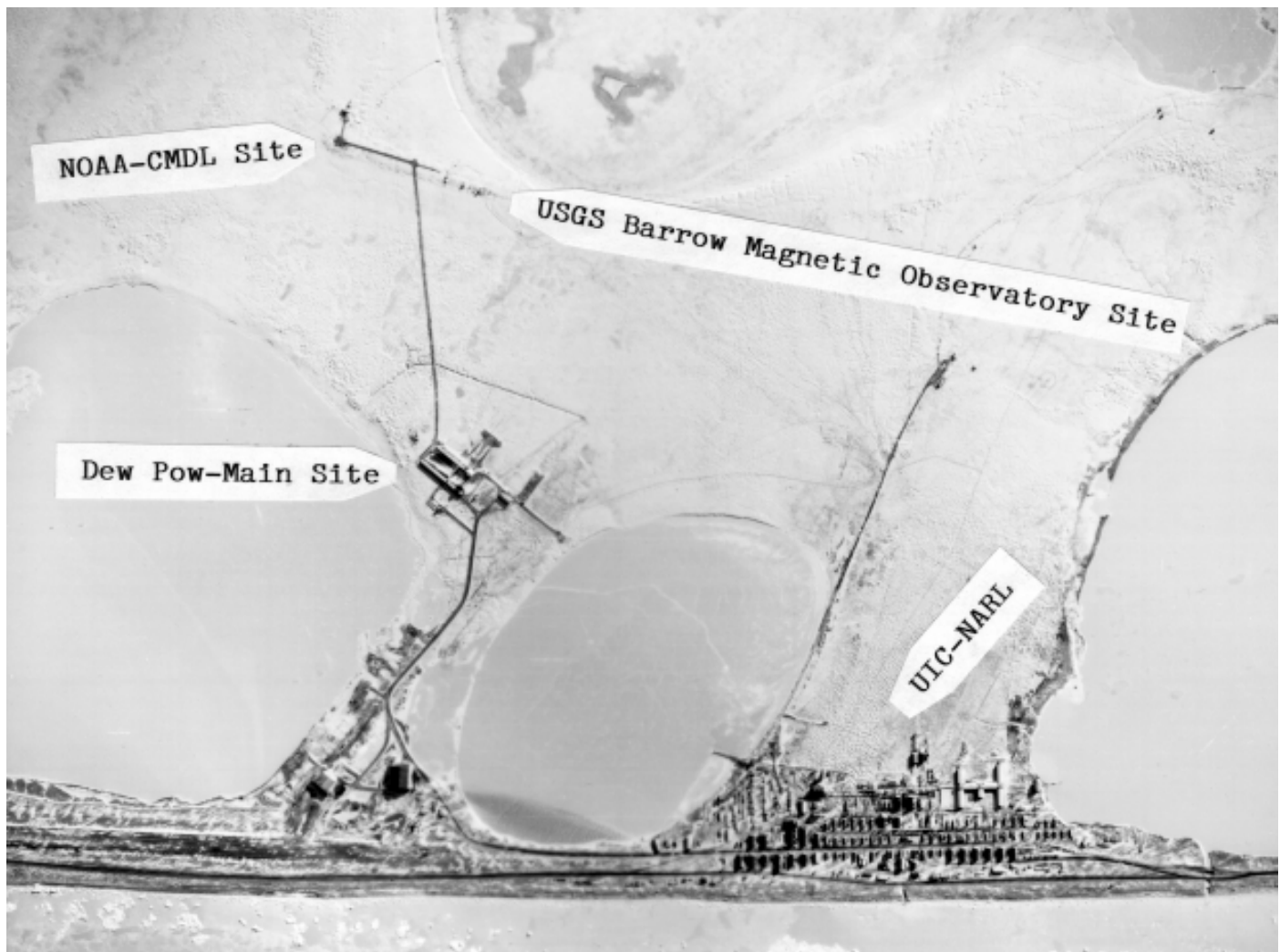


Fig. 1. Aerial view of the Barrow Magnetic Observatory, DEW Pow-Main, NOAA-CMDL sites, and the main UIC-NARL Camp.

three miles west of the NARL facility and east of the village of Browerville. Construction was completed and the observatory started operating in 1949.

The absolute instruments initially used were:

1. a Ruska Declination/Horizontal Intensity Magnetometer for measuring the absolute value of declination and horizontal intensity;
2. a Ruska Earth Inductor for measuring the inclination (dip) angle of the magnetic field.

From the dip angle and horizontal intensity, the vertical intensity of the field could be computed. A Ruska magnetograph was used to measure the variations in declination, horizontal intensity and vertical intensity. It consisted of a recorder, and declination, horizontal-intensity and vertical intensity variometers. The magnetograph operated continuously, recording data 24 hours a day with absolute observations made weekly when possible. Access to the facilities was by a tracked vehicle or on foot due to their remote location.

One geophysicist was assigned to operate the observatory on one-year contracts. Living quarters (room and board) for the scientific personnel were provided by the NARL. The observatory operated in this mode from 1949 to 1957. As part of the International Geophysical Year (IGY) Study in 1958, additional facilities were constructed east of the NARL facilities and south of the Distant Early Warning System (DEW) Line site, "Pow-Main." A new magnetograph and instrument-control building was constructed in 1957 on property controlled by the NARL about one-half mile south of DEW Pow-Main. The magnetograph at the Browerville site was moved to this new site and one additional magnetograph, a "Rapid-Run magnetograph," was installed to measure rapid fluctuations of the magnetic field.

In 1975 all of the facilities and operations were consolidated at the observatory DEW site (Fig. 1) as follows:

1. New absolute piers were constructed at the DEW site using new techniques to reduce pier shifting caused by seasonal changes in the permafrost. Upon completion of the piers, the absolute building at the Browerville site was moved to the DEW site and put over the new piers (Fig. 2).



Fig. 2. Barrow Magnetic Observatory, Absolute Building.

2. The mechanical “conventional” and “Rapid-Run” magnetographs were removed.
3. The magnetograph building at the DEW site was remodeled to better control and stabilize the temperature.
4. In place of the old mechanical operating magnetograph’s, a new “Fluxgate” magnetometer was installed in the remodeled magnetograph building (Fig. 3). Data from the Fluxgate magnetometer was transmitted by cable to a recorder building (Figs. 4 and 5) and then by satellite and by phone to the USGS office in Golden, Colorado.
5. A new “Proton” magnetometer was installed to measure directly the intensity of the Earth’s total field.



Fig. 3. Barrow Magnetic Observatory, Magnetograph-Magnetometer Building.



Fig. 4. Barrow Magnetic Observatory, Recorder and Utility Building, front entrance.



Fig. 5. Barrow Magnetic Observatory, Recorder and Utility Building, rear side.

6. Quartz Horizontal Magnetometers “QHM” were installed to measure the absolute value of horizontal intensity.
7. The vertical field was computed using the total field and horizontal intensity.
8. With the installation of the Fluxgate magnetometer, the observatory was converted to an unmanned facility, operated as a satellite station of the College Observatory.
9. The NOAA-CMDL personnel at facilities adjacent to the Barrow observatory assisted in operating the observatory on a contractual arrangement.

The changes made in the consolidation of the observatory in 1975 resulted in significant improvements in the operation and data quality. These improvements are the result of better understanding and knowledge obtained over the years about the hostile environment, new techniques for construction of piers and facilities for sensitive scientific instruments, and the availability of new technology and better instrumentation.

In 1992, the declination magnetometer and the QHM were removed and a Declination-Inclination Fluxgate Magnetometer (DIM) was installed to make absolute observations.

In 1998, a new facility (Fig. 6) was constructed at the observatory's DEW site and a newly developed quasi-absolute instrument was installed, further to improve data quality.



Fig. 6 Barrow Magnetic Observatory, Quasi-absolute Facility (left), and DIDD Magnetometer (right).

In addition to the primary mission of the Barrow Magnetic Observatory, scientists stationed at the observatory and the government agencies responsible for the operation have cooperated with numerous scientists, other governmental agencies, and universities in conducting scientific projects on the Barrow Magnetic Observatory site that did not interfere with the magnetic projects. In 1964, through the cooperative efforts of the NARL Director and the USC&GS Seismology Division Chief, a seismograph was installed at the site in a seismic vault constructed twenty feet below the surface in the permafrost (Fig. 7). This project is still in operation recording earthquake activity. The data from the seismograph is transmitted by dedicated



Fig. 7. Barrow Magnetic Observatory, entrance to underground seismic vault, with Magnetometer-Magnetograph Building in background.

communications lines and satellite to the Alaska Earthquake Information Center at the University of Alaska Fairbanks through the Alaska Tsunami Warning Center Network.

As we enter into the year 2000, the observatory is operating under the guidance of the USGS Geomagnetism Group of the Central Region Geological Hazards Team in Golden, Colorado. The observatory is operated with observation and oversight services provided by the NOAA-CMDL personnel at Barrow on contract with USGS. Observatory data are transmitted routinely by satellite, computer, and fax to the Golden office and to the College Observatory in Fairbanks, Alaska, which reviews and checks observations prior to transmitting them to the headquarters in Golden.

For information on the Barrow Magnetic Observatory, contact the author, or:

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U.S. Geological Survey
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Denver Federal Center, Denver, CO 80225

In conclusion I pay tribute to all of the resident staff who have participated in operating or assisted in operating the Barrow Magnetic Observatory for 50 years as they braved and coped with the daily challenges:

William Schmieder, USC&GS, 1949-51
John L. Bottum, USC&GS, 1951-53
Richard Green, USC&GS, 1953-54
A.R. Franzke, University of Alaska, 1954-57
Merle Young, University of Alaska, 1954-57
Robert Leonard, University of Alaska, 1954-57
Lloyd Gill, USC&GS, 1957
Ralph Barrella, USC&GS, 1957-58
Ardo Meyer, USC&GS, 1958-60
Willis Jacobs, USC&GS, 1960-63
Terrence Hardiman, USC&GS, 1963-64
Marvin Carlson, USC&GS, 1964
Patrick Clark, USC&GS and ESSA, 1964-66
Gene Phillips, ESSA and NOAA, 1966-71
Robert Holbrook, NOAA, 1971-72
William O'Neil, NOAA and USGS, 1972-73
Emerson Wood, NOAA and USGS, 1973-74
Walt Brunner, local scientist at Barrow, 1974
Ilo Gassoway, USGS, 1974
Gary Brougham, USGS, 1974-May 1975

Thanks also go to the following NOAA-CMDL chiefs who have provided checks, observations, and some oversight of the Barrow Magnetic Observatory in its unmanned mode of operation:

Larry Westerman, 1975; Emerson Wood, 1976; Tom DeForr, 1977-78; Dave Smith, 1979-80; Randy Fox, 1981-82; Dan Beard, 1983; Steve Fahnenstiel, 1984; and immortal Dan Endres, 1985-present.

The Role of the Office of Naval Research and the International Geophysical Year (1957-58) in the Growth of the Naval Arctic Research Laboratory

Maxwell E. Britton¹

ABSTRACT: The Naval Arctic Research Laboratory (NARL) was operated by the Office of Naval Research from 1947 to 1981. NARL was created to provide field and laboratory support for research programs sent there under ONR contracts, under subcontracts of an ONR contract to the Arctic Institute of North America (AINA), and such other programs as approved by the Chief of Naval Research. Important human resources were available to NARL from nearby Barrow, and other villages of arctic Alaska. The intelligence, broad knowledge, skills and adaptability of the Iñupiat people made them excellent and continuing partners in accomplishing ONR's research goals. The International Geophysical Year (IGY) of 1957-58 provided NARL with experience in the establishment and maintenance of research stations on pack ice, previously supported by landing on fixed airfields. IGY experience led ONR and NARL to initiate a series of ice station-based studies, designed to be established and serviced by airdrops and landings, using aircraft no longer dependent upon fixed airstrips.

Key Words: Arctic Ocean, Arctic Basin, drifting ice stations, International Geophysical Year, IGY, University of Alaska, Arctic Institute of North America, AINA, Office of Naval Research, ONR

The Office of Naval Research (ONR) came into existence in 1946 in the heady days immediately following World War II when the scientific leadership of the country, recognizing the wartime contributions science and engineering had made, was intent on stimulation of peacetime research beyond anything previously known. ONR was charged to plan, originate, coordinate and support basic and applied research in a joint effort with civilian institutions and scientists by funding them through contracts and grants. The ideas would be those of the scientists, and their research would usually be open, unfettered by security restrictions, and freely published in the world's journals of choice. Not until four years later did the National Science Foundation come into being with much the same philosophical base as ONR, and with a much broader mandate to serve the public scientific interests of the United States.

Just a little over one year after its origin, ONR created the Arctic Research Laboratory (ARL), later renamed Naval Arctic Research Laboratory (NARL), and still later UIC-NARL (Fig. 1). The Laboratory was a contractor-operated arm of ONR, to which ONR would send approved research tasks for field and laboratory support. Those approved included ONR contracts and subcontracts, other U.S. Navy in-house or contracted projects, projects of other federal agencies; and those otherwise supported by federal funds that could meet legal requirements of ONR. Whatever the NARL experience would prove to be, its



Fig. 1. The now-Iñupiat-owned facilities, known as UIC-NARL, 6 km NE of Barrow, Alaska. Principal research laboratories and living quarters occupy the H-shaped Building #360 at right center. Photo: L. Nakashima, 1976, collection of J. F.

growth throughout its full life span was nurtured and sustained by ONR with the cooperation and assistance of other elements of the Navy.

NARL began under the administration of the Environmental Biology Branch of ONR with the concept that it would be headed by an academic scientist, designated as Scientific Director (SDNARL), who would organize and lead a research team primarily in his own research field. This person's institution would hold the contract for operations. By 1954, the Arctic Program was well known, unsolicited proposals to ONR were accelerating, and there was no further need to visit institutions to promote and seek worthy research. Once there was no longer any relationship between the SDNARL and the way research proposals

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were received and approved in ONR, the function and the title were dropped.

Dr. Louis O. Quam, who headed the Geography Branch, Earth Sciences Division of ONR, took over responsibility for the Arctic Research Program in 1951 when interest waned among the biological scientists. He gave new life and excellent leadership to the Program until 1959 when he gave up its management to become Director of the Earth Sciences Division. He ended his long tenure in ONR in 1967 upon appointment to the position of Chief Scientist of the Office of Antarctic Programs, of the National Science Foundation.

Two early actions taken by Dr. Quam were to have long-lasting influence on both NARL operations and the research programs sent here to Barrow for support. The first was a contract with the Arctic Institute of North America (AINA) to perform various advisory committee functions and, very importantly, to develop and administer a program of subcontract research which, combined with contracts directly negotiated by ONR plus other approved tasks, rounded out the annual NARL program. This Agreement with AINA was valuable to the total program because it permitted entry and support of large numbers of smaller research tasks that could not be justified under direct ONR contract.

An ONR Arctic Program staff member sat in on the deliberations of committees reviewing research proposals, participated in preliminary decisions, and ultimately approved or rejected proposals recommended by AINA. Early screening eliminated many proposals which were clearly unacceptable to the ONR Program. All expenditures of funds for research subcontracts required individual authorization by ONR. The various Directors of NARL were also invited at times to participate in the review committee meetings. As the program at NARL grew in volume and diversity, close coordination of tasks in the field became important. In order to achieve this coordination in a manner to serve best the interests of the investigators while making the most efficient use of available resources it was essential that the views and advice of the DNARL be obtained early in the review process.

Dr. Quam's second major contribution was to make new arrangements for NARL operations. The Johns Hopkins University held the contract at the time to provide logistics support, but was dissatisfied with the relationship, which gave the university no responsibility for scientific programs. This was the same problem

that had caused Swarthmore College, the first operator, to give up the contract (Reed and Ronhovde, 1971:71). Despite this history, the University of Alaska agreed to take the contract although there was much controversy on its campus regarding the University's role. President Ernest N. Patty found sufficient merit in the contract to justify acceptance. During the administration of Patty's successor, William R. Wood (1960-1973; now *President Emeritus*), there was enthusiastic public support of everything associated with NARL; the Laboratory was considered to be a distinct asset to the University and the State of Alaska.

Here I digress to relate a bit of personal history. I had been an investigator at NARL for three summers, 1952-54. In December 1954 Dr. Quam offered me the new position of Scientific Officer for the Arctic Program. Out of reluctance to leave my faculty position at Northwestern University, I declined the offer. Then the long arm of chance intervened in the course of NARL. Only about 10 days later a tragic event in my family made the financial rewards of Dr. Quam's offer very attractive, and in March 1955, I accepted.

Reporting for duty to ONR in September 1955, I found that I could provide Quam with a first-hand appraisal of NARL's major needs. My first priority was to provide for a permanent, full-time, resident director. The position clearly required arctic experience as well as familiarity with NARL and, of critical importance, a willingness to accept the residency and tenure requirements.

Among persons I had known and observed in daily routines at Barrow, Max Brewer (Fig. 2) stood out as one who got along well with associates and who was especially generous in his helpfulness to others. In fact, he exhibited personal traits that could stand him in good stead as head of NARL. Additionally, he had a background in both physical sciences and engineering. His interest in the position was determined and the door was open to share ONR's wishes with the University of Alaska.

President Patty expressed understandable reservations to ONR's initiative, and hurried to our office in Washington to resolve the issues. Primarily he defended his right and privilege to select a member of his own faculty for the position or to name any other who might need to be added to the University's payroll. In the end, recognizing the importance attached to this appointment by ONR, Dr. Patty was satisfied by the reassurances and evaluations, and agreed to offer the position to ONR's candidate. Brewer accepted appointment as



Fig. 2. Max C. Brewer, Director of NARL in Library of Building #250, 1968. Photo: D. W. Norton.

DNARL in May 1956 and took up his duties in September. He was to make this position synonymous with dedication and distinction and to set standards of performance for every DNARL to emulate to the very end of U.S. Navy operation of the Laboratory.

With Brewer's appointment, research and research support missions seemed unified; that is, the ONR/AINA research end and the NARL research support end of the Arctic Research Program responsibilities were secure. For the first time, there was a promise of stability and permanence that heralded progress for Navy and other U.S. research in the Arctic. The record supports the optimism of the time. It had been hoped that Brewer would hold his position at least five years; he stayed for 15. After nine of those years, President Wood, in 1965, conferred upon him the Honorary Doctor of Science Degree in recognition of the distinction with which he had served the University of Alaska. In 1962 he had also been recognized by conferral of the U.S. Navy's Distinguished Public Service Award.

As the Scientific Officer (later Director of Arctic Research Program, ONR) and the Director of NARL pursued mutual goals for the growth of NARL, the two

of us in those positions were able to select and employ persons who were to prove important to our own success. Two such appointments, one in Washington D.C. and one at NARL, greatly strengthened our respective staffs.

First, the ONR Arctic Program obtained the valuable services of Ronald K. McGregor, CDR U.S. Navy, in 1966. He came for a two-year tour of active duty and, upon his retirement from the Navy in 1968, was recruited as a civilian scientist. McGregor was given the responsibility for monitoring all research contracts in physical sciences. When I resigned from ONR in 1970 it was my pleasure to recommend him to succeed me as Director, Arctic Program. He served that position with distinction, spanning a full decade of NARL's history, until his retirement in 1981.

Second, at NARL in 1961, Brewer selected John F. Schindler as his Assistant Director. Schindler had arrived at NARL in 1960 as a young investigator and brought to his new administrative role many skills and talents. He too served with distinction, and in 1970, when Brewer resigned from his long and successful career at the position, Schindler was appointed the second DNARL (eighth of 10 Directorships of the Laboratory, 1947-1980).

In his discussion of the relationship of NARL to Petroleum Reserve No. 4, John Schindler (this volume) briefly treats the history of the early Directors, ending with the one-year service of Mr. Ted Mathews in 1954 and Dr. Ira Wiggins in 1955. When Brewer returned to Barrow in August 1956 as the new Director, he found that many changes had occurred during his nearly two years of residency in California. He rapidly organized his staff, made new hires as necessary, and adjusted to his new role, as well as to the changes. The principal change had been the takeover of the Navy Camp by the U.S. Air Force in support of its construction of the Distant Early Warning Line (DEW) of radar stations. A host/tenant agreement allowed use of stipulated Navy facilities and the Air Force agreed to furnish support for NARL functions. The camp was under management of an Air Force contractor and Brewer immediately entered negotiations with the Air Force over interpretations of the host/tenant agreement. He was an informed and determined protector of all Navy property and other residual assets from the Pet 4 exploration program.

Also at this time, final plans were under way for the International Geophysical Year (IGY) scheduled for the period 1 July 1957 to 31 December 1958. The

Laboratory was not involved in the planning, but was to host a group conducting geophysical and oceanographic observations. Farther afield, in the Brooks Range, the U.S. Air Force was to establish and support two stations for glaciological and meteorological studies (Fig. 3). Although these stations were independent of NARL they did need, and called for, assistance at times. ONR authorized DNARL to provide such help as possible. NARL responded to many routine requests and also to one instance of emergency, involving a death, at McCall Glacier.



Fig. 3. IGY Research Station, McCall Glacier, Brooks Range, Alaska. View southward up glacier. Station is the small cluster of structures near center of image. Photo: reproduced from Kodachrome transparency by Robert Mason, 1958.

A major and long-lasting impact of the IGY evolved from its establishment of two research stations on drifting ice platforms in the Arctic Ocean—Station ALPHA on pack ice and Station BRAVO on Fletcher's Ice Island (T-3). These stations were established by the Air Force, utilizing large aircraft and prepared ice runways. The Air Force system was expensive, such that stations on floe ice were vulnerable to ice fracture and loss of prepared runways. ALPHA had a relatively short life and, if the IGY programs were to be completed, they had to be replaced. Louis Quam, planning to take over a station after IGY, if possible, was instrumental in obtaining emergency funding to establish a replacement station, named Station CHARLIE. During these fast-unfolding events, DNARL, using available light aircraft and personnel, while relying upon knowledgeable Inupiat from Barrow, rendered varied services to the Air Force on the ice, off the ice, and to moving people and things back and forth.

Following the IGY, Quam obtained permission from the Chief of Naval Research to initiate a plan that Max Brewer and the author had generated to set up drifting stations without prepared airstrips. Such stations would be relatively small and austere, therefore, less costly; but without sacrificing safety and comfort. The first of these stations, Arctic Research Laboratory Ice Station-I (ARLIS-I) was established with icebreaker support in September 1960, and was re-supplied by light aircraft (Figs. 4 and 5).



Fig 4. Icebreaker USS Burton Island, supporting establishment of Arctic Research Laboratory Ice Station-I (ARLIS-I), 12 September 1960. Photo: Kodachrome transparency by J. F. Schindler

The ARLIS-I effort was the beginning of NARL's capability to carry Navy programs far to sea in the Arctic Basin. As the NARL fleet of aircraft grew, its capability was to be utilized repeatedly to establish and maintain a series of both floe- and ice island- research stations. Our successes led us into some mischief with our Soviet colleagues, which LeSchack (this volume) recounts.

Also, in the early post-IGY years there was a significant shift toward physical science research at NARL, or away from the biological sciences that had previously dominated the program. This was in part a consequence of the IGY activities.

Subsequently, of course, ecological studies with their interdisciplinary blend of biological and physical components, were to reach their greatest intensity and significance at NARL in the 1970s during the Tundra Biome Project of the International Biological Programme (Brown, this volume). On the physical



Fig. 5. ARLIS-I on drifting ice floe, 19 March 1961, with John F. Schindler, Assistant Director NARL in foreground. Photo: J. F. Schindler.

side, IGY drifting station research programs, especially those on the ice pack, laid the basic scientific and logistic foundation for the sophisticated AIDJEX Project (Arctic Ice Dynamics Joint Experiment) also accomplished in the 1970s (Weeks, this volume).

My role over the years in NARL entitles me to conclude by expressing my appreciation for countless good deeds and acts of friendliness extended by the Iñupiat people to me, my associates, and all others who made NARL the success it proved to be. I shall never forget my Iñupiat friends, Kenny Toovak, Sr., Pete Sovalik, Harry Brower, Sr., Tommy Brower, Al Hopson and many others.

Of many memories, I shall share three in concluding:

On a flight one summer to the Colville Delta to see Dr. H. Jesse Walker (Joe Felder was the pilot), Max Brewer asked me to take a case of celery to George Woods. George was a very fine Iñupiat gentleman, quite elderly at the time, living with his wife Nanny in a very nice cottage on the Delta (Fig. 6) They were a most delightful couple and very hospitable. When it was time to leave, George gave me a huge frozen fish for Brewer and said, “give this to Max, he’s such a dear boy.”

Joe Ahgeak worked a lot for me in the field in 1953 and 1954. Joe came to me one morning with a big smile on his face and said his wife had given birth to a son whom they had named Max, after me. I am very proud of that fact, and that I found myself on the same program back in Barrow celebrating the NARL 50th



Fig. 6. George Woods, Iñupiat gentleman, in summer view of his home environment on the Colville River delta, 1961. Photo: H. J. Walker.

Anniversary with my namesake, Max Ahgeak. Also, I wish to record here my admiration and respect for the achievements of Joe’s daughter Edna who, having earned her doctorate at Stanford, one of the great universities of the country, now presides over Ilisagvik College. Joe would be happy and proud of the successes of his children as I am sure Mrs. Ahgeak is. We have exchanged Christmas greetings for many years.

Finally, I share a story about Frankie Akpik as a young man. Brewer, Schindler and I, and others, were in Iceland in May 1965 when we had to evacuate the ARLIS-II people, including Frankie, Percy Nusunginya and James Itta, from the ice island in the Greenland Sea and over to Iceland. When everyone was safe and rested, we tried to show the men around the local area just so they would have the experience. It is an interesting country and there are sheep just about everywhere. I asked Frankie if he knew what the animals were and, with a big grin, he said, “they are sweaters.” When I asked about the little lambs he said, “those are little sweaters.” He had a good joke on me and I still think of sheep as ‘big and little sweaters.’

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Monitoring of Worldwide Fallout-related Radiation in North Slope People and Animals

Wayne C. Hanson¹

ABSTRACT: Radioecological research on worldwide radioactive fallout in arctic food chains, especially those in northern Alaska between 1959 and 1980, defined routes, rates, and concentrations of several radionuclides that originated from nuclear weapons tests conducted by China, France, Great Britain, the Former Soviet Union, and the United States. Our studies of high latitude populations documented radiation exposures of up to 200 times those received by subarctic and temperate populations. Radioecological research nevertheless concludes that arctic subsistence is a healthy lifestyle.

KEYWORDS: radionuclides, arctic food chains, lichens, caribou, nuclear weapons tests, fallout, Cesium-137, Strontium-90, Anaktuvuk Pass

INTRODUCTION

Implications of fallout are important in circumpolar regions, where unique combinations of lichens, caribou/reindeer (*Rangifer*), and predators lead to arctic peoples dependent upon their environment for subsistence. This food chain results in direct routes of exposure, compared with human populations at more southerly latitudes. Our studies were conducted over the general area of northern Alaska between 66° North latitude and the Arctic Ocean, constituting 310 000 km² (120 000 square miles). Within that area are diverse ecosystems, four major caribou herds, and several Iñupiat and Athabaskan villages, representing four major ethnic groups. Two peaks of stratospheric fallout important to circumpolar arctic ecosystems occurred during 1953-1959 and in 1964, reflecting atmospheric nuclear weapons test series by Great Britain, the Soviet Union, and the United States. Pulses of lesser fallout deposition occurred during 1967-1970, following nuclear weapons tests by France and the People's Republic of China.

METHODS, RESULTS, DISCUSSION

We proceeded from a semi-quantitative study of radionuclides in various compartments of the northern biosphere—initially in the Cape Thompson area—to a wider investigation of components of food webs essential to northern villages. Radioiodine-131 originating in prompt fallout from medium-energy-yield nuclear weapons tests was measured in thyroid glands of caribou and reindeer from northwestern Alaska about two months after the beginning of a new series of nuclear tests by the USSR in September-

November 1961. Concentrations in thyroid glands of ¹³¹I by Alaska caribou and reindeer were about one-half those of mule deer collected at the same time in Colorado and Washington. This difference illustrates the roles of global weather patterns and atmospheric phenomena, which produce the deposition of prompt fallout primarily in rainfall belts around the world.

The correlation of worldwide fallout deposition and precipitation, and the practicality of estimating integrated fallout in a geographic region by careful soil sampling have long been known. Inventories of cesium-137 (¹³⁷Cs) in soils of northern Alaska and in lichen carpets were determined throughout our studies. Ratios of several natural (potassium-40, polonium-210 and lead-210) and man-made radionuclides (strontium-90, cesium-137, plutonium-238, plutonium-239+240 and others) were useful for establishing inventories and comparing their behavior in various ecosystem components.

Lichens and mosses are known to be particularly efficient accumulators of fallout radionuclides, and were basic to our studies of worldwide fallout in the lichen-caribou/reindeer-carnivore (including man) food webs of northern Alaska. The critical role of lichens as a winter food of caribou and reindeer resulted in substantial concentrations in their tissues. Intensive sampling of lichens at 20 locations from the Alaska-Canada border to the Chukchi Sea (including three locations on the wintering range of caribou that provided critical food for native villages) showed no significant differences in ¹³⁷Cs and ⁹⁰Sr concentrations between three widespread lichen species, three physiographic provinces, or sampling years. We concluded that the

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radionuclides in the base of the major food web of interest were reasonably constant, and that major departures from established seasonal patterns would be due to shifts in animal behavior and their metabolism, in upper levels of the food web.

Concentrations of ^{137}Cs in caribou and reindeer flesh samples follow an annual cycle, with low values during fall, and maximum values in spring months. This cycle reflects the migratory habits of the animals and their change of basic forage from lichens in winter, to sedges and other green plants (low in fallout radionuclides and high in potassium) during summer. Animals' body water turnover (higher in summer) also produces an abrupt decline in ^{137}Cs concentrations in soft tissues. Levels of ^{137}Cs in other herbivores such as moose (*Alces*) and Dall sheep (*Ovis*) on ranges near those utilized by caribou showed no significant seasonal pattern, and were substantially lower than caribou values.

Strontium-90 concentrations in bone samples of caribou and reindeer were about 1000 times the levels in flesh samples. Values were relatively stable until 1962, then began a sharp increase after the major nuclear weapons test series of 1961-1962, to about three times their former levels by 1966-1969. A Concentration Ratio of 7.6 for caribou bone/lichen existed during the higher plateau period, when a condition of 99% of equilibrium existed.

Plutonium (Pu) concentrations in caribou bone samples during the 1971-1975 period of maximum values in lichens were barely detectable. Concentration Ratios relative to lichens were usually near 0.02 for ^{238}Pu and 0.001 for $^{231,240}\text{Pu}$. Concentrations of these fallout constituents in upper levels of food webs were so variable and near minimum-detectable levels that large (up to 100 g of ash) samples were required. Concentration Ratios of plutonium isotopes were 140-180 for lichen/soil; 0.004-0.005 for caribou flesh/lichen; and 0.01-0.09 for wolf bone/caribou bone.

Extensive sampling of flesh and bone of carnivores (wolves—*Canis*, foxes—*Vulpes*, *Alopex*, and wolverines—*Gulo*) from northern Alaska, 1960-1969, showed a repeated annual pattern of ^{137}Cs concentrations, with a rapid increase through fall and winter that paralleled the increase of ^{137}Cs in caribou. Wolves contained twice the concentrations observed in foxes and wolverines, both of which are primarily scavengers of wolf-killed caribou and consumers of small mammals that contain much lower ^{137}Cs concentrations. The Concentration Ratio for ^{137}Cs in

wolf flesh/caribou flesh at 80% of equilibrium at time of sampling averaged 2.7.

Measurement of ^{90}Sr in human bone samples in the native populations of northern Alaska, obviously, was not feasible. Therefore, two mathematical models, one based on strontium kinetics in human bone and another based on ^{90}Sr ingestion rates via caribou meat, were used to predict ^{90}Sr concentrations in skeletons of *Nunamiut* residents of Anaktuvuk Pass. Results showed that caribou meat contributed 97% of total ^{90}Sr intake by adult men in 1965, which decreased to 79% in 1975 as use of caribou for food decreased. Predicted skeletal values in adult males were slightly lower than values reported in New York City adults until 1980 and subsequently declined by 9% per year. Predicted skeletal burdens of ^{90}Sr in Anaktuvuk Pass residents born in 1954 and 1959 achieved maxima in 1971 and 1974, respectively; concentrations in children born in 1964 were still increasing in 1979, but at a lower level than older-age cohorts.

Cesium-137 body burdens among adult men in Anaktuvuk Pass often reached 200 times those of comparable residents of the contiguous U.S. We made 45 measurements of ^{137}Cs body burdens of all available residents of Anaktuvuk Pass during five specific periods of each of the years 1962-1979. Radiation doses ranged from 60 mrad (= 0.06 mSv)/yr in 1962 to about 140 mrad (= 0.14 mSv)/yr during the 1964-1966 maxima, and then decreased to 8 mrad (= 0.008 mSv) in 1979. In addition, Anaktuvuk Pass residents received annual dose rates of about 100 mrad from natural polonium-210; 3-15 mrad from ^{90}Sr ; and a few mrad from iron-55 (^{55}Fe). Total radiation dose from natural and worldwide fallout sources thus ranged from 120 to 250 mrad (= 1.2 - 2.5 mSv) per year. This dose is in addition to an annual radiation dose of 3.6 mSv to a member of the general U.S. population, but remains well below 100 mSv, the level at which estimates of risk might be detected by direct observations in epidemiological studies. Our attempts to observe chromosomal aberrations in several *Nunamiut* men with histories of high ^{137}Cs body burdens shortly after the 1964-1966 period of maximum exposure were unsuccessful.

Our studies were continuously supported by the U.S. Atomic Energy Commission, re-named the Energy Research and Development Administration and later the U.S. Department of Energy. I deeply appreciated the support of Dr. Max C. Brewer and John F. Schindler, Directors of NARL for most of the years of our studies, and the outstanding logistical support of the NARL staff.

Finally, the cooperation and hospitality of the several villages involved in our investigations was without equal, and is warmly acknowledged. Anaktuvuk Pass was always a center of our attention and its people especially admired for their cooperation.

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Frontispiece: Six of the first seven Directors of NARL. Left to right, Max Brewer, G. Dallas Hanna, Ira Wiggins, George MacGinitie, and Laurence Irving. Photo, courtesy of John F. Schindler, taken in Fairbanks in 1969 on the occasion of dedication of the new main Laboratory at NARL, Building #360. Only Ted Mathews was unable to attend. The fact that five people can represent six Directorships is explained by Ira Wiggins' having served as Director during two separate periods.

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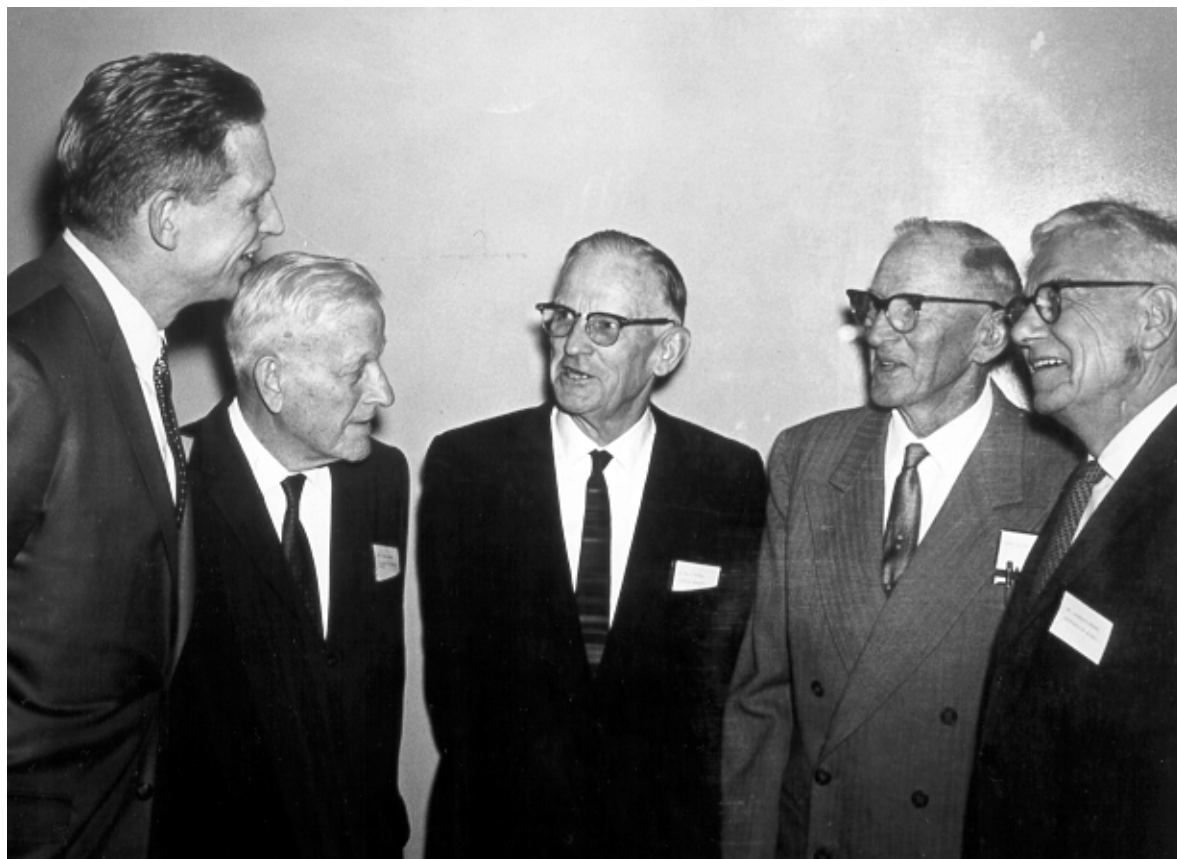
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Cold Adaptations and Fossil Atmospheres: Polar legacies of Irving and Scholander

Robert Elsner¹

ABSTRACT: Twentieth century polar science made important advances under the guidance of the first investigative team at NARL, Scholander and Irving. Their biological studies of cold adaptations revealed new insights into the ways in which animals, birds, and plants thrive in conditions that intuitively appear hostile. They were alert to broader implications of that research, as demonstrated by an extrapolation from biology to geophysics in the discovery that fossil atmospheric gases can be recovered from ancient glacial ice, thereby opening a window on climate history.

Key words: gas diffusion, metabolism, insulation, investigative teamwork

From 1947 to 1949, research at the Arctic Research Laboratory (ARL) was launched by two giants of 20th century science, Per Scholander (Fig. 1) and Laurence Irving (Fig. 2). Together, they initiated biological studies of cold adaptation in animals and plants, and achieved new understandings of the mechanisms that support their survival in the arctic environment. Their innovative experimental studies continue to stimulate the thinking of polar scientists and students today.

The best known of these early investigations resulted in a series of publications that revealed cold adaptations of mammals, birds, fishes, and insects. In a series of remarkably simple comparative experiments, they clarified the fundamental principles by which animals' metabolism, body temperature, heat loss, and insulation are all interrelated. Other studies explored the mechanisms by which arctic plants tolerate extreme cold (see Box A).

From their earliest days at the Barrow Laboratory, Irving and Scholander promoted science as a team effort by investigators and support staff (Schindler, this volume, Fig 2). The work published by their team gave much impetus to the field of polar physiology that the subsequent expansion of the field is deeply in their debt. These and many other pioneering accomplishments are more than sufficient justification for recommending National Historic Site designation for all or part of the NARL camp. [The tradition of teamwork among scientists and staff radiated from NARL. Carson (this volume) and Walker (this volume) note that multidisciplinary teamwork positively influenced fields of inquiry far outside the Laboratory's initial focus on plant and animal physiology. Norton and Weller (this volume) trace how long NARL's

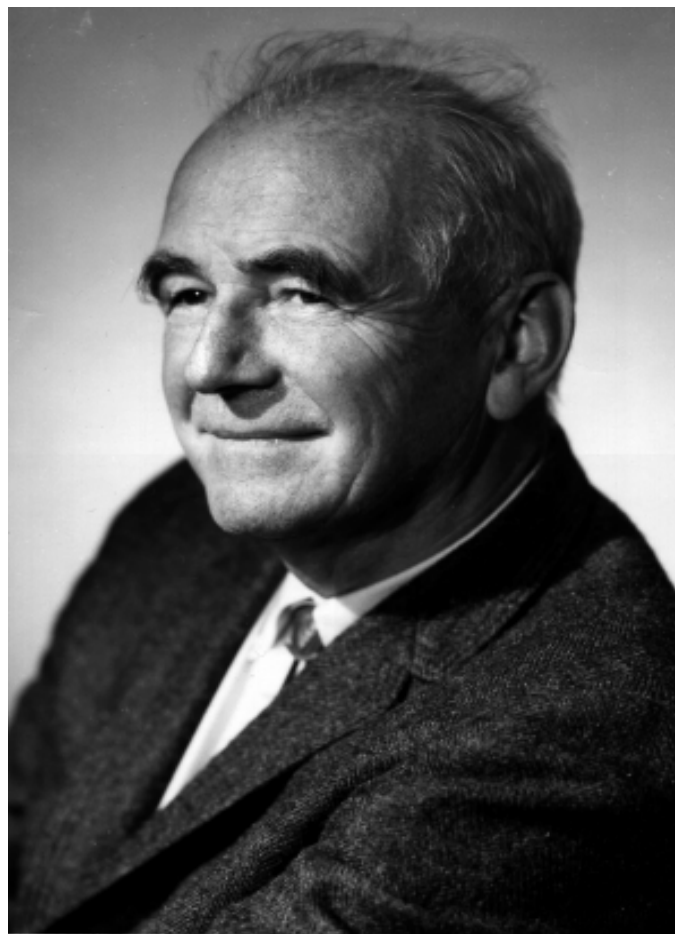


Fig. 1. Per F. ("Pete") Scholander. Photo: reprinted from Scholander, P. F. 1990, Enjoying a life in science, with permission of the University of Alaska Press.

teamwork imprint has lasted among investigators in the Arctic: Editor]

By contrast with Irving and Scholander's studies of cold adaptations, it is not so well known that another far reaching development of contemporary science also originated in their early biological studies at ARL. The beginnings of the currently important studies of

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Fig. 2. Laurence N. ("Larry") Irving. Portrait detail from painting by Fred Machetantz, which hangs in the Lobby of the Irving Building, University of Alaska Fairbanks.

fossil atmospheres retrieved from polar glaciers and ice fields originated in research undertaken by the Scholander-Irving team. Glaciologists had known for many years that glacier ice contains bubbles under pressure. It took the genius of Scholander, delving into the mysteries of organisms frozen in ice, to make the insightful leap to ancient atmospheres trapped in long-frozen ice and to provide modern glaciologists and climatologists with a novel and valuable tool. Scholander had noted that some small invertebrates remained embedded all winter in ice near Barrow, and this observation led him to question the diffusion rates of atmospheric gases through ice. Finding little information on this topic in the literature, he undertook some simple experiments to determine its nature. His studies revealed that oxygen and carbon dioxide diffused extremely slowly through thin layers of ice. The initial results were published in a paper, entitled *Studies on the physiology of frozen plants and animals in the arctic* (Scholander et al., 1953). More detailed studies were completed by Scholander's student, Edvard Hemmingsen. It became clear that the transfer of carbon dioxide through a thin layer of ice proceeded at a rate of less than one-millionth of its diffusion in water, oxygen even less.

The recognition that this discovery might lead to determinations of ancient atmospheres must rank as one of the more remarkable scientific inferences of the century. The first publication (Scholander et al. 1956) stated the concept in these words:

...Considering this extremely slow rate, the relatively enormous diffusion distances in the glacier, and the large quantity of gas held under pressure in the ice, it would seem possible that gas trapped in the glacier would remain un-

changed for millennia. Analysis of such gas could therefore give information about the atmospheric composition at the time the ice was formed.....

(Scholander et al. 1956)

Subsequent research on this topic resulted in additional publications. (see Box B)

The universality of science is well illustrated in this story. Scholander the biologist had a keen eye for all of Nature's curiosities. His insightful mind took the conceptual leap that has led to the present-day applicability and importance of this technique for examining atmospheric history and for enlarging our current understanding of global climate change. It all started at ARL. The stories of those early ARL days are told in Scholander's (1990) own colorful words in his posthumously published autobiography, *Enjoying a Life in Science*.

Irving and Scholander positively influenced the lives of many young people. My personal debt to them is long-standing. I was privileged to meet them in the early spring of 1942, along with George Llano and Susan Irving, who would become Susan Scholander. They had climbed to the summit of Mount Washington in New Hampshire to conduct tests of cold weather survival equipment and techniques for the U.S. Army Air Corps. I was then working as a meteorological technician at the Mount Washington Observatory. The stimulating experience of interacting with them during that operation strongly shaped my later career choices, ultimately leading to working visits to NARL in the 1950s, research projects with Irving and Scholander, and spending 12 years in Scholander's laboratory at Scripps Institution of Oceanography.

In recent years I have continued to work happily and productively at the present UIC-NARL where I have enjoyed the outstanding cooperation of Barrow people and the North Slope Borough Department of Wildlife Management. Barrow remains an extremely important northern outpost of American science, thanks in large part to the pioneer efforts of Scholander and Irving and to the foresight and enthusiasm of the Barrow community.

BOX A: COLD ADAPTATIONS—CLASSIC PAPERS

- Scholander, P.F., Walters, V., Hock, R., and Irving, L. 1950. Body insulation of some arctic and tropical mammals and birds. *Biological Bulletin* 99:225-236.
- Scholander, P.F., Hock, R., Walters, V., Johnson, F., and Irving, L. 1950. Heat regulation in some arctic and tropical mammals and birds. *Biological Bulletin* 99:237-258.
- Scholander, P.F., Hock, R., Walters, V., and Irving, L. 1950. Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation and basal metabolic rate. *Biological Bulletin* 99:259-271.
- Scholander, P.F., Flagg, W., Walters, V., and Irving, L. 1952. Respiration in some arctic and tropical lichens in relation to temperature. *American Journal of Botany* 39:707-713.
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- Scholander, P.F., Flagg, W., Hock, R. J., and Irving, L. 1953. Studies on the physiology of frozen plants and animals in the arctic. *Journal of Cellular and Comparative Physiology* 42, Supplement 1, 56 pp.
- Scholander, P.F. 1955. Evolution of climatic adaptation in homeotherms. *Evolution* 9:15-26.

BOX B: FOSSIL ATMOSPHERES—CLASSIC PAPERS

- Scholander, P.F., Kanwisher, J.W., and Nutt, D.C. 1956. Gases in icebergs. *Science* 123:104-105.
- Coachman, L.K., Hemmingsen, E., and Scholander, P.F. 1956. Gas enclosures in a temperate glacier. *Tellus* 8:415-423.
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An Overview of Early Research on Small Mammals in Arctic Alaska

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ABSTRACT: Taxonomic, life history, physiological, and parasitological studies of the more prominent members of Alaska's arctic mammal fauna are reviewed in their historical connection to the Naval Arctic Research Laboratory.

KEY WORDS: Arctic small mammals, *Lemmus*, *Dicrostonyx*, *Microtus*, *Marmota*, *Mustela*

Through the efforts of members of several early voyages, the composition of the terrestrial mammalian fauna along the arctic coast of Alaska had become nearly completely known to European and American naturalists by the end of the 19th Century. With the aid of the Iñupiat, additional records were obtained subsequently by Anderson (1924), Bailey and Hendee (1926), Charles D. Brower (whose records were reported by Hall in 1929), and others, but it was not until after the Second World War that extensive field-work became practicable in the more remote regions of arctic Alaska, when air-transport was readily available.

The establishment of the Naval Arctic Research Laboratory near Point Barrow in 1947 was an event of the utmost importance to biological research in the Arctic. Indeed, for many of us, the opportunities provided by that institution for fundamental research in the field, with laboratory facilities immediately at hand, have never again been equaled. At the NARL, we had the benefit of the indispensable help of the Iñupiat, who shared their unique knowledge, and whose guidance in the field prevented ill-advised actions on the part of persons unfamiliar with the arctic environment. Coincidentally, in 1948, the Arctic Health Research Center, U. S. Public Health Service, was established by an Act of Congress to address problems relating to the health of the indigenous peoples of Alaska. I was employed by the AHRC in late 1948, with responsibility for the investigation of zoonotic diseases. In March 1949, at the invitation of the Director of the NARL, Dr. Laurence Irving, I was able to make use of the facilities at Barrow, as I did during several years thereafter.

Compatible with the interests of the investigators involved, some of the first studies undertaken at the

NARL had the objective of defining the physiological characteristics of plants and animals adapted to low temperatures (e.g., three papers by Scholander and coworkers, 1950a, 1950b, 1950c; Scholander *et al.*, 1953; and Irving and Krog, 1954). That work was supported mainly under a contract between the Office of Naval Research and Swarthmore College. Research on small mammals with greater emphasis on observations in the field began on a small scale in 1950, and it expanded greatly during the following years.

Terrestrial mammals of comparatively few species inhabit the low tundra along the coast of northern Alaska. Most prominent are lemmings of two species (family Arvicolidae). The brown lemming, *Lemmus sibiricus* (Kerr), (Fig. 1) has been of particular interest because of the regular pattern of high-amplitude fluctuations in its numbers. That phenomenon of course had long been known to the Iñupiat, but Murdoch (1885:102) was evidently the first European to recognize and report that lemmings of both species varied in numbers from year to year on the arctic slope. The brown lemming is closely related to *Lemmus lemmus* (L.), of northwestern Eurasia (Rausch and



Figure 1. The brown lemming at Barrow. (Photo: Robert L. Rausch)

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Rausch, 1975), whose presence in great numbers in some years in northern Fennoscandia was attributed to their falling from the sky during storms (Högström, 1749; see also Elton, 1942:211).

The second species (see above) on the arctic slope is the varying lemming, *Dicrostonyx rubricatus* (Richardson) (Fig. 2). Of all rodents, members of the genus *Dicrostonyx* appear to be the most highly adapted to the arctic environment. The varying lemming is designated Kilangmiutaq (dweller of the sky) in Iñupiaq, a name derived logically from the observation that such pure white rodents are present only in winter, and that their trails appear to arise spontaneously on the snow-surface, as if they had fallen with the snow.

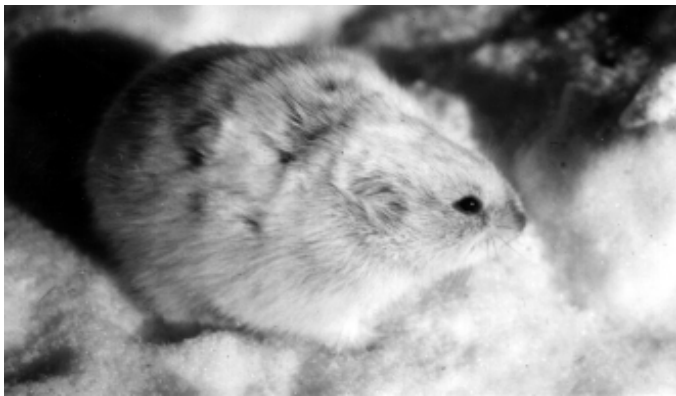


Figure 2. The varying lemming, in winter pelage, from the arctic slope of Alaska. (Photo: Robert L. Rausch)

On 17 March 1949, when I arrived at the NARL, I went out to set traps for rodents, but little evidence of their presence was noted, except for several brown lemmings that had emerged onto the snow-surface, where they had died. Brown lemmings characteristically inhabit the subnivean space during winter, where they feed on vegetation. Attempts to trap the animals in the subnivean space were unsuccessful, since they were not attracted by bait. By late May, however, as snow-free areas appeared on the tundra, the rodents were still abundant, but dead specimens were numerous. All I obtained were examined for the presence of parasites and evidence of disease, with the hope of finding some indication of the cause of the natural mortality. I did not find it, but observations made in 1949 were reported (Rausch, 1950), and two species of cestodes were later described from lemmings (Rausch, 1952). Varying lemmings were few in 1949; those obtained were found dead, scattered on the tundra, or were taken from the nests of Snowy Owls (*Nyctea scandiaca*), where they had been brought by adults as food for the nestlings.

After the severe decline in numbers in 1949, brown lemmings were rare in the vicinity of Barrow in 1950. That year, Daniel Q. Thompson, of Ripon College, began an investigation of the biology of that rodent, under contract with the Office of Naval Research (1950-1952), and with further support from the Arctic Institute of North America. Thompson traced the change in numerical density of the lemmings from a low level in 1951 to a peak in 1953. He found that the tundra vegetation had required two summers to recover from the effects of the peak population in 1949 and, with use of enclosures, that available forage again had been almost wholly utilized by the peak population by 1953. A mass-migration of the rodents occurred locally in 1953. Dr. Thompson concluded that the population of brown lemmings fluctuated in a self-perpetuating cycle in which reproduction was conditioned by the availability of forage and by mortality from predation. He noted that nesting of predatory birds (Snowy Owls, and jaegers, *Stercorarius* spp.) was correlated with the numerical density of the rodents (Thompson, 1955).

In April 1949, Clay Kaigelaq, Thomas Brower, and I went to Anaktuvuk Pass, in the central Brooks Range, where we made contact with the Nunamiut, who were arriving to establish their summer camp at Tulugaq Lake. At that time, the Nunamiut traveled widely in winter for trapping and hunting, and arrangements were made to obtain the skinned carcasses of animals that they trapped (mostly foxes and wolves), for study relating to zoonotic diseases. That first meeting led to an association extending over the next 25 years, and to much learning; the materials collected in the Brooks Range formed the basis for numerous reports relating to zoonotic diseases and to the taxonomy of arctic mammals (Rausch, 1951, *et seq.*). Beginning in 1949 as well, many specimens, especially from marine mammals, were obtained through the generous cooperation of the Iñupiat residents at Barrow, Wainwright, and other villages situated within what is now the North Slope Borough.

In 1951, Frank A. Pitelka and coworkers began biological investigations at the NARL. Although their initial interest concerned the avian fauna, they also observed events leading to the peak density of brown lemmings in 1953. Soon, Dr. Pitelka established a series of permanent traplines, in order to follow changes in the populations in all of the major types of habitat within the general vicinity of Barrow. His investigations were supported by the Arctic Institute of North America under contract with the Office of Naval Research from

1955 to 1969, and thereafter by the National Science Foundation.

The long-term observations made by Pitelka and coworkers were comprehensive, with attention to diverse factors that might be involved in the population-dynamics of the brown lemming. Cyclic peaks were recorded in 1953, 1956, 1960, and 1965. The numbers of lemmings persisted at relatively low levels for some years after 1965, and it was considered that a combination of atypical weather and severe predation by mouse weasels, *Mustela nivalis* L., might have suppressed the potential for a peak in 1968 or 1969. Relatively high densities were evident again in 1971; in that year as well, varying lemmings were present in numbers greater than any recorded previously by the investigators at NARL.

The information obtained by Pitelka and coworkers related to various aspects of the biology of lemmings, such as: characteristics of microtine cycles (Pitelka, 1957a, 1957b); reproduction of brown lemmings (Mullen, 1968); predation by Pomarine Jaegers, *S. pomarinus* (Maher, 1970); nutritional ecology of brown lemmings at Barrow (Batzli and Pitelka, 1983); and habitat use by lemmings at Barrow (Batzli *et al.*, 1983). The results of the long-term investigations concerning lemmings and other arvicolidids on the arctic slope were reviewed by Pitelka and Batzli (1993).

As part of those investigations, Henry E. Childs, Jr., conducted surveys of mammals (and birds) during four summers (1957-1960) in the vicinity of Cape Sabine, on the arctic coast to the northeast of Cape Lisburne. Childs (1969) obtained data concerning arvicolidids and other small mammals.

During 1951-1952, James W. Bee and E. Raymond Hall collected mammals in the vicinity of thirteen base-camps (including Barrow) in northern Alaska, and summarized records of distribution from the literature. They also reported important data on the biology of the mammals (Bee and Hall, 1956). Their project was supported under a contract between the Office of Naval Research and the Museum of Natural History, University of Kansas.

Over the years, several other investigations also were concerned with some aspect of the biology of lemmings: circadian patterns in arctic microtines, by Richard Andrews, Creighton College; intestinal bacteria of lemmings, by William L. Boyd, University of Georgia; metabolism of arctic rodents, by Ingrith J. Deyrup, Barnard College; physiology of varying lemmings, by

Donald S. Farner, University of Washington; ecology of predators of lemmings on Banks Island, by William Maher, Santa Barbara State College; and anaerobic bacterial flora of the cecum of lemmings, by Richard McBee, Montana State College.

The arctic ground squirrel, *Citellus parryi* (Richardson), formerly designated *C. undulatus* (Pallas), a hibernator, also was subject to much investigative effort at NARL. Studies by Wilber and Musacchia (1950) concerned metabolism of fat. Results of ecological research were reported by W. V. Mayer, University of Southern California (Mayer, 1953a, 1953b). Studies by G. Edgar Folk and coworkers, University of Iowa, examined the daily cycle of activity of the ground squirrel (Folk, 1963), and physiological measurements were made with use of implanted transmitters (Folk and Folk, 1964). Comparative studies concerning circadian rhythms in arctic rodents, including *C. parryi*, by R. H. Swade and C. S. Pittendrigh (1967), Princeton University, were supported in part by NARL.

An investigation concerning the biology of a second species of sciurid, the arctic marmot (also known as Brower's marmot), *Marmota broweri* Hall *et* Gilmore, was begun in 1977 by Thomas F. Albert, University of Maryland, whose appreciation for the opportunities to conduct biological research in the Arctic led to his many years of participation in and service to the scientific program of the North Slope Borough. The marmot is limited in distribution mainly to the Brooks Range; it was earlier considered to be a subspecies of the hoary marmot, *M. caligata* (Eschscholtz), until its chromosomal and biological characteristics indicated that its closest affinities are with the northeast Siberian *Marmota camtschatica* (Pallas) (cf. Rausch and Rausch, 1971). Brower's marmots hibernate in family groups, and remain in the winter den for ca. 8-9 months of the year. Since entrances to the winter dens are sealed, my colleague Darrell Williams (physiologist at the Arctic Health Research Center) and I became interested in measuring any changes in composition of respiratory gases during the period of hibernation. In artificial dens established in central Alaska, near Fairbanks, we found that temperatures in nest-boxes of the hibernating marmots attained levels as low as -25°C, with levels of oxygen as low as 4%, and of carbon dioxide as high as 13.5% (Williams and Rausch, 1973). We were not able to investigate overwintering conditions in the subnivean spaces of lemmings and other arvicolidids; such studies, concerning levels of respiratory gases in that environment, and the extent if any to which the small mammals have adapted, would be of interest.

The mouse weasel, *Mustela nivalis*, the smallest member of the order Carnivora, is an important predator on lemmings in years when populations are near peak levels. Many know that weasel as *Mustela rixosa* (Bangs), as formerly in the literature it was designated. Except for some observations on body-temperature by Folk *et al.* (1977), the biological characteristics of the mouse weasel in the Arctic remain poorly known.

Some of the small mammals recorded from Alaska's arctic slope received no more than nominal attention from the investigators at NARL, namely, three species of shrews (Soricidae) and three of voles (Arvicolidae). The shrew usually designated *Sorex cinereus* Kerr occurs widely on the arctic slope; its status taxonomically probably will remain somewhat controversial until definitive studies can be made (cf. Rausch and Rausch, 1995). *Sorex tundrensis* Merriam appears to be uncommon. *Sorex monticolus* Merriam, formerly designated *Sorex obscurus*, is known north of the Brooks Range from only a few specimens.

The northern red-backed vole, *Clethrionomys rutilus* (Pallas), is not commonly present in far northern Alaska. Bee and Hall (1953) reported one specimen from Barrow and a small series from Umiat. The vole occurs widely from the Brooks Range southward. The northern vole (also called the tundra vole), *Microtus oeconomus* (Pallas), evidently is not present in the vicinity of Barrow, but it has been found to be numerous at times at Point Lay and at Atqasuk. From the latitude of the Brooks Range and southward in Alaska, it occurs widely. The narrow-skulled vole, which has been designated *Microtus miurus* Osgood, is the only North American representative of the subgenus *Stenocranius*. Its status, taxonomically, is not clearly defined, but as determined from cytogenetic comparisons and from experimental cross-breeding in which offspring were indefinitely fertile (cf. Rausch and Rausch, 1968, and unpublished data), the specific name for that vole is indicated, on grounds of priority, as *Microtus abbreviatus* Miller. It is abundant in the highland tundra of the arctic slope.

Of the small terrestrial mammals in northern Alaska, the brown lemming and the arctic ground squirrel have been the most intensively studied there. Other species received less attention. As is evident from the present review, the cumulative effect of the various studies has been nonetheless of impressive magnitude. Biologists interested in the arctic fauna will be always grateful to NARL and the Office of Naval Research, whose support made possible some significant advances in our understanding of the arctic ecosystem.

For myself, I express gratitude for the opportunity to investigate some zoonotic diseases on the arctic coast, where such work would have been very difficult without the advantages provided by NARL. I received as well the kind hospitality and assistance of the Inupiat, in Barrow and Wainwright and other villages on the coast and in Anaktuvuk Pass in the Brooks Range. They shared with me their knowledge of the fauna and flora of the Arctic, transmitted among themselves over generations. They were, and are, my mentors.

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Early Polar Bear Studies at NARL

Jack W. Lentfer¹

ABSTRACT: This paper describes how NARL was instrumental early in the organized research on polar bears from 1966 to 1972. Studies continued at NARL after the transfer of management authority from the State of Alaska to the federal government until the end of the 1970s.

Key words: *Ursus maritimus*, Marine Mammal Protection Act (1972), satellite-tracking, denning, mark-recapture studies, contaminant levels, parasites

Prior to 1966, polar bear management in Alaska was based mainly on data from hunters and bears they killed. Following the first international polar bear meeting in Fairbanks in 1965, the Alaska Department of Fish and Game (ADF&G) initiated intensive research, much of which was conducted from the Barrow Naval Arctic Research Laboratory. Research by the Department continued until 1972 when the Marine Mammal Protection Act transferred polar bear management authority from the State of Alaska to the Federal government. The U.S. Fish and Wildlife Service continued research out of NARL after 1972.

An initial ADF&G project in 1966 was an attempt to develop a census method by counting bears and their tracks on the sea ice from low-flying fixed-wing aircraft. This was unsuccessful because of the difficulty of sighting white animals against a white background and determining how many animals were flown over and not counted.

Marking of polar bears was also attempted at Barrow in 1966 by a research group from the University of Maryland. They were supported by fixed-wing aircraft and attempted to capture bears by delivering an immobilizing drug with a syringe gun from the ground and from a fixed-wing plane. Several bears died, most from drug overdoses, and the project was considered unsuccessful.

In 1967 the Alaska Department of Fish and Game started a mark and recapture program based at NARL. Bears were tracked on the sea ice in late winter and spring, and immobilized with use of a syringe gun from a helicopter. A fixed-wing plane carried fuel, helped find bears, and provided a safety factor. The technique of immobilizing from a helicopter as developed at

Barrow (Lentfer 1968) has been adopted by other researchers and is still widely used. The mark and recapture study continued through 1976 and also included data from bears marked in the Bering Strait, the Cape Lisburne area, and the Kaktovik area. Marked animals were recovered by recapturing and by hunters. A report on data from 809 marked animals provides information on population sex and age composition, survival rates, minimum and maximum breeding ages, litter size, breeding interval, and breeding season (Lentfer *et al.* 1980). Recovery of marked animals suggested two sub-populations of polar bears, one to the west of Alaska and one to the north of Alaska, with a line extending northwest from Point Lay separating them (Lentfer 1974, 1983). Radio-tracking of bears since then has confirmed different sub-populations in the Beaufort and Chukchi/Bering seas, but with some intermixing (Amstrup 1995, Garner *et al.* 1990).

Denning in winter snow dens, where cubs are born and spend their first 3 months, is a critical time in polar bear life history, and NARL-based studies provided information on denning. The first confirmed den on drifting sea ice was found northwest of Barrow 165 kilometers offshore (Lentfer 1975). Presence of new-born cubs and their tracks as far as 728 kilometers offshore also indicated offshore denning (Lentfer and Hensel 1980).

Use of earth-orbiting satellites for tracking polar bears started at NARL. Bears were brought in from the ice and held in the NARL animal colony to develop radio attachment methods and to test radio signal transmission to satellites and accuracy of satellite location fixes. Data were obtained from a limited number of bears in the wild (Kolz *et al.* 1978). Since then, the U.S. Fish and Wildlife Service has had an intensive satellite-tracking program in the Beaufort, Chukchi and Bering seas.

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IRISH: ONE SMART POLAR BEAR

During the late 1970s, I worked as an animal caretaker at the NARL Animal Research Facility (ARF). For a year and a half, I had the great privilege to care-take some of the world's finest examples of Carnivora and Rodentia. At that time there were 25 wolves, 3 wolverines, about 10 arctic foxes, 3 red foxes, and dozens of lemmings, ground squirrels and marmots; and a polar bear named "Irish". This was a fascinating and unusual job by any measure, and one that was to change the course of my life.

During those 18 months I spent considerably more time with the animals than with people. I came to know each animal by name and by their individual idiosyncrasies. Patterns emerged. The wolves were quick as cats, really did "eat like wolves" and always sang a group howl at the Camp's noon siren. The Arctic marmots were friendly, snuggled with each other and chirped when I entered the building. The ground squirrels and Tom's misplaced ground hogs, however, fought endlessly and would at times make meals of each other. Some of the wolves were very aggressive. Old Duke would certainly have made a meal of me had I slipped and fallen in the cage while shoveling away his last meal. In the next cage was a "socialized" female named June, which loved to go for walks on a leash.

Irish was different from the other animals. Each time I went to his cage I found him doing something different - often fiddling with something with this huge paws as if trying to figure out how it worked. You could feel his mind working as he studied and manipulated his "toys": a 12-foot section of rope, a truck tire, a billet of wooden piling, and a bowling ball. Playing in his ten-foot diameter pool was another favorite pastime.

After another few months, it dawned on me that this animal was at least as smart as I. Years earlier, he had figured out how to lift the sliding door that divided his cage. So when cleaning or feeding, caretakers had to slide a large metal rod into the door to prevent his lifting it and perhaps making bear food of the caretakers. After a few years, Irish figured out how to slide the bar to release the door. By the time I arrived, after his 12 years or so of captivity, we had to slide in the pin *and* lock it in place. Having to outwit Irish to that degree seemed impossible, but the caretakers who trained me assured me that it was wise to follow their advice.

One of Irish's favorite games was tug o' war. This was a fairly simple affair but Irish clearly played with a motive. We would feed his hemp rope into cage, let him grab it with his teeth, and the contest would begin. Pulling against his 1,000-pound mass was futile but good fun nonetheless. He would pull the rope to his chest with one paw and then back up using three legs. Slowly bulldozer-like he would pull you up to the cage bars then he'd quickly let loose of the rope and lunge for you. Of course, when he let go of the rope, you would fly backwards onto the cement floor and he wouldn't have much chance. Still he'd stick the end of his great paw through the bars hoping to snag you.

Had he got hold of a caretaker, the outcome could have been very serious. Witnessing Irish pulling his 16-inch truck tire through 8-inch gaps between his cage bars was guaranteed to instill awe for power of these animals. This "tire torture" was another of his favorite games. I would push the tire against the bars and he would sink one canine into it, which was enough to get the tire started. Then he'd place his huge forearms against the bars and bench press the tire—groaning and screaming—on its short agonized journey through the bars. I imagined a reluctant ringed seal being pulled through a small breathing hole in the sea ice in the same manner. We caretakers realized that if ever he got a firm hold, one of us could be pulled through the bars like a rag doll (imagine a person going through a pasta maker). Or would he leave you alone? I was very curious about this. What would Irish do if you went into his cage? I had a strong urge to just walk in and give him a hug, but of course, I never did. For safety, we always fed him and cleaned his cage in pairs.

The strength of a polar bear is impressive but not unexpected. A couple of unique experiences illustrate interesting, revealing, even eerie things about this animal's behavior, or mind. After a tug of war game, Irish obviously always "won" undisputed possession of the rope and thereafter would play with it in his cage. One morning, when starting to feed and clean, I noticed the rope carefully laid out linearly, atop and following the curve of the 4-inch wide rim of the pool in the middle of his cage. This orderly arrangement of the rope seemed so odd that I asked the other caretaker if he had placed the rope there. He hadn't. Another time I watched Irish pick up his bowling ball and try unsuccessfully to place it on the pool's rim. He used his muzzle and one paw to pick it up.

Everything he did was precise, graceful, and purposeful. Based on poise and mannerism alone, I would rate Irish a *highly* intelligent animal, perhaps rivaling many of the Primates.

Irish played a pool game that we regarded as something akin to “catching the seal.” Of all of his activities, pool time was his favorite. When we filled the tub Irish would climb in, often taking his wooden piling with him. He would sit erect. The tub was almost four feet deep but water would barely cover his belly. In this sitting position, you could see how huge he was. Seated, his nose nearly touched the approximately 7-foot ceiling of the cage. Once the pool was full, he would push the floating wooden block beneath the surface. When Irish released the block, it burst to the surface. This was his cue to pounce on it with ferocious power, grabbing it with arms and teeth. Water would explode from the pool hitting every wall, the ceiling and anyone close by. He would repeat catching the seal until the pool was essentially empty; then the fun was over until the water truck returned to fill his pool. Having emptied his pool, he would slowly lift his gaze and stare directly—deeply—into you with his small bloodshot eyes as if to say, “Someday you’re going to be in a cage and I’m going to have the keys.”

Another time Irish *autopsied* a lab mouse. I can’t say how the mouse actually got into the cage but it was amazing to watch a 1,000 pound bear chase this tiny animal around and around the cage, his nose 2 inches from the mouse’s tail. After a half dozen circuits around the cage, with his massive hands he killed the mouse, then slowly and meticulously dissected the animal on the cage floor. He closely inspected the small carcass but did not eat it.

Iñupiat legends about polar bears have that they are really “people in a bear hide” That is why the hunter must treat the bear as a guest after killing it. From what Irish taught me, I think the old-timers had it right.

J. C. "Craig" George

Other studies have included examination of polar bear tissues for presence of parasites and environmental contaminants during the period 1967-1972 (Lentfer 1976). *Trichinella* larvae were present in 64 percent of 292 bears examined. Fat samples from nearly all bears examined contained polychlorinated biphenyls (PCB) and chlorinated hydrocarbons including the DDT group, hexachlorobenzene, dieldrin, and endrin. Organochlorinated hydrocarbons were at such low levels that they probably had a minimal effect on bears. The mean PCB level was relatively low (about 1.9 ppm in fat tissue) compared to levels, apparently nonlethal, reported in some other mammals. All liver samples examined for mercury contained low levels, with bears to the north of Alaska having significantly higher levels than bears to the west (Lentfer 1987). Thermoregulation in polar bears was studied in captive animals at NARL (Fig. 1). Bears use fat and pelt insulation, heat dissipation through footpads, and panting for thermoregulation (Oritsland *et al.* 1974). Blix and Lentfer (1979) suggested that newborn cubs depend on closeness of the mother and protection of a snow den to maintain body heat. A high metabolic rate and highly effective fur insulation are important for thermoregulation when cubs leave the winter maternity den at 3 months of age.

Other studies at NARL provided descriptions of polar bear milk content and Vitamin A in liver. Polar bear milk has a fairly high fat content, about 31 percent (Cook *et al.* 1970). Polar bear liver contains 15 000-



Fig. 1. “Irish,” captive polar bear at the NARL Animal Research Facility. Photo, J. C. George.

30 000 units per gram of vitamin A (Lewis and Lentfer 1967).

Research at NARL and elsewhere in the Beaufort Sea has provided the basis for an important management agreement between the North Slope Borough of Alaska and the Northwest Territories of Canada. This agreement allocates harvest and provides other guidelines for taking of bears in the southern Beaufort Sea by Alaskan and Canadian hunters (Nageak *et al.* 1991). Other management agreements pending for the population of bears shared by the United States and Russia in the Chukchi and Bering seas are an agreement between the two countries and another agreement between Natives of Alaska and Chukotka.

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Overview of Early Research on Large Mammals in Arctic Alaska

G. Edgar Folk, Jr.¹

ABSTRACT: Responses to the arctic environment by large mammals were studied in the facilities of the Naval Arctic Research Laboratory. Continuous darkness, and continuous daylight elicit responses in mammals' biological clocks. The main tool used in this part of the study and others was the Iowa Implantable Radio Capsule, used to record physiological functions. Another tool was the impact capsule for delivery of a harmless drug, new at that time. An abdominal operation to insert the radiocapsule was devised; it proved harmless to all animals studied, including more than 20 species of mammals and birds. The capsules allowed us to define the nature of hibernation in three species of bears: polar, grizzly, and black bears. Another study that used drawn blood samples instead of radiocapsules showed that polar bears develop high levels of cholesterol and triglycerides after fasting for several months, probably because of the low levels of omega-3 fatty acids in their diets.

Key Words: biological clocks, radiotelemetry, impact capsules, implantable physiological radiocapsules, bear hibernation, Omega-3 fatty acids

INTRODUCTION

By calling information “encyclopedic” we tend to mean that it is comprehensive, systematically accessible, and sometimes prescriptive. When adults guide children to the *Encyclopaedia Britannica* or to comparable computer web pages, how often do they think about the sources and processing of encyclopedic knowledge? NARL, which hosted hundreds of scientists each year, provides some interesting case studies of the acquisition and refinement of encyclopedic knowledge. Many scientists were curious and eager to learn from Chester Lampe, Pete Sovalik, Kenny Toovak, and Harry Brower, Sr. all they could about this interesting part of the world. NARL, in effect, promoted creation and sharing of encyclopedic knowledge about this demanding environment.

It is not easy to answer the question, “what became of information shared with NARL’s visiting scientists?” Sometimes years pass, and then the results of a particular study suddenly reappear, picked up by some distant scientific endeavor. NARL’s 50th Anniversary provides an occasion for contributors to “report back” to the community on the fate of knowledge and information developed from work at the Barrow Laboratory. Some information remains encyclopedic, used as basic stepping-stones to further advances in basic understanding. Other arctic investigations, by contrast, have led directly to information applied in clinical medicine. Requests for reprints of published arctic

information from medical scientists serve as indicators of clinical relevancy. In this chapter, mention of clinical application means that requests for reprints of the results of our projects at Barrow were received from physicians and other medical professionals in Canada, the United States, and Europe. Specific examples of arctic research are described here to illustrate both encyclopedic and clinical fates of information derived through NARL.

BIOLOGICAL CLOCKS

This study was motivated by pure encyclopedic curiosity. Investigations were made on the arctic ground squirrel (*Spermophilus undulatus kennicottii*). Despite using this wild arctic rodent, and despite their encyclopedic intent, knowledge of biological clocks does apply to human problems, such as those encountered in long distance jet travel, eastward or westward across conventional time zones.

Humans and other animals can measure time. When deprived of such natural external signals as sunrise and sunset, an internal clock takes over. The internal clock in us and other vertebrates tends to be “off” by about an hour either way from 24-hr accuracy. That is, when the internal clock takes over, an organism tends to keep schedules of either 23 or 25-hour days. The new timing is called a “circadian” (Latin, *circa*-: close to; + *-die*: day) rhythm. Influence of internal clock function is manifested variously. The person or animal deprived of external cues continues to show large peaks and valleys each day in body temperature and in

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blood chemistry. These variations tend to occur faster (23-hr circadian rhythm) or slower (25-hr circadian rhythm) than in organisms whose schedules are reset daily by external signals.

The internal circadian timing is under the control of a physiological and anatomical programmer, called the “biological clock.” Various lines of scientific evidence lead physiologists, anatomists and psychologists to believe that this “clock” is located in the hypothalamus of the vertebrate brain. At the end of a jet flight from Anchorage to London, a traveler finds that the clocks in England read 9 hours ahead of (i.e., later than) Alaska Time. Adjusting to British clocks and British sunrises and sunsets requires resetting the traveler’s behavior, and adjusting the traveler’s peaks and valleys in body temperature and blood chemistry—a process that takes some people five or six days.

To relate these remarks to arctic ground squirrels (Fig. 1), Dr. Dick Swade’s and our own curiosity focused on what happens to the biological clock in these animals when they experience no sunrises or sunsets for a period of 82 days of continuous light in the summer at Barrow. We found that they managed to keep to a 24-hour schedule instead of adopting a 23 or 25-hour schedule. We concluded that the squirrels can read the position of the sun in the sky as a signal to keep them on a 24-hour schedule (Folk 1962).

The first Iñupiat contribution to this project was to provide us valuable information about the natural



Fig. 1. Comparative appearance of the arctic ground squirrel (left) and the thirteen-lined ground squirrel (*Citellus tridecemlineatus*), which ranges from the U. S. Border with Canada south to the Gulf of Mexico. Arctic ground squirrels are the largest-bodied member of the genus. This specimen is carrying a radiocapsule weighing 15.9 g in its abdominal cavity.

history, behavior, and life cycle of the arctic ground squirrel. They also provided us with the specimens for conducting physiological research, and shared anecdotal information about how their personal daily habits were influenced by the 82 days of continuous light in summer.

SELECTING AN IMMOBILIZING DRUG

Before an appropriate drug became available, studies on large arctic mammals, including polar bears, were blocked by concern over the number of wild animals unintentionally killed in biologists’ attempts to immobilize them for installing radio collars. In the absence of a safe drug in 1960 to study large mammals, a behaviorist wanting to study polar bears on the ice, and others interested in grizzly bears in Yellowstone Park, tried to use succinylcholine to immobilize the animals. The weight of the animals had to be estimated precisely and many bears died because it was difficult to make this estimation accurately. The Department of Fish and Game eventually prohibited the further use of succinylcholine on polar bears Alaska.

Fortunately, at about this time, clinical medicine had experimented with a new immobilizing drug that presented far lower risk of fatal dosage. If an animal’s body weight proved less than estimated, such that researchers administered an overdose of phencyclidine hydrochloride, the animal simply stayed immobilized for a longer period. Donation of this drug by the Parke Davis Company to our project marked a change in the feasibility of acquiring biological information from large animals that had to be immobilized. Parke Davis contributed the drug in return for our reporting findings on appropriate dosages for mammals and birds. We worked out the appropriate dosage for a number of arctic mammals, including the subarctic lynx (*Lynx canadensis*). Phencyclidine hydrochloride bears the common name of Angel Dust and was marketed as Sernalyn. We always followed the immobilization process with a respiratory anesthetic such as ether or fluorothane. We delivered the immobilizing drug by means of CO₂-cartridge-powered guns with the drug in impact-delivering capsules.

Our determinations of species-appropriate dosages of the newly available phencyclidine at NARL in cooperation with Parke Davis helped pave the way for many other researchers’ studies on large mammals elsewhere in the world. Experiments that depended on the new immobilizing drug are described below.

THE INVENTION OF PHYSIOLOGICAL RADIO CAPSULES

Until the 1950's physiologists depended on making measurements such as of the heartbeat, body temperature, and oxygen consumption by means of wires or tubes running from a recording instrument to the animal. There was much talk of the need of being able to transmit physiological information by radio but it had not been done successfully. Curiously, the first and some of the most dramatic experiments were carried out in polar regions. In 1959 Eklund, working in the Antarctic on penguins wanted to measure the incubation temperatures of birds sitting on eggs when the ground temperature was possibly -40°C and the wind-chill was -200°C . He devised a small radio that would measure temperature and broadcast it to a tent some distance away. He introduced these radios into the eggs of two species of birds and successfully measured the temperature of the incubated eggs in this fashion. He published this technique in *American Scientist* (Eklund and Charlton 1959) and many biologists in various parts of the world were inspired to imitate the technique in their own laboratory or field investigations. We developed similar transmitters for projects at NARL, and are still using them in my laboratory today (Folk *et al.* 1995).

Radiotelemetry was actually introduced to the Arctic in historic and dramatic fashion in 1952. The famous pioneering cardiologist, Dr. Paul Dudley White, investigated details of the heartbeat of a bowhead whale (*Balaena mysticetus*) by radio in 1952. You can imagine his excitement as the whale was pulling his small boat while its heartbeat was being measured by telemetry. What was the importance of the observation? Dr. White was an expert on the transmission of the electrical impulse that signals the heart muscle to contract ("beat"). This electrical impulse travels from the top of the heart (atrium) to the bottom of the heart (ventricle). Dr. White wanted to study the extremes of this transmission by comparing the transmission anatomy of the smallest mammal, the shrew, which has a heart rate of 1000 beats per minute, with the anatomy of the transmission of the heartbeat in a whale, in which the enormous heart contracts only 10 to 14 times per minute. Dr. White could not have obtained the information about whales without help from the Inupiat, particularly that of a man named Joe Clark. Joe provided the boat, the information about the whales, harpooned the whale so it could pull the boat, and then brought White and the other scientists home safely.

I particularly enjoy recounting this scientific adventure, shared between a resident of Clark's Point (south of Pt Hope) and such an eminent scientist. Dr. White was to become famous as President Eisenhower's personal physician, for seeing the President through recovery after Eisenhower suffered a heart attack while in office. For this, and for his many contributions in the field of cardiac physiology, Dr. White was honored with a commemorative United States postage stamp. This account also reminds us of the caliber of scientists who realized the importance of conducting research in polar regions. Along with Eklund, Dr. White led the way toward the common use of physiological radio capsules. These made our experiments at NARL possible.

In the wake of the achievements in polar regions by White and Eklund, we developed in our laboratory the Iowa Implantable Radiocapsule, using the electronic wizardry of Prof. Warren Essler. This radiocapsule was designed for placement in the body cavity (Figs. 2-5).

THE HIBERNATION OF BEARS

This topic was presented and described in detail in the dedication symposium of 1969 (Folk 1969). After that report there was more information obtained on the hibernation of black bears (*Ursus americanus*), grizzly bears (*Ursus horribilis*), and polar bears (*Thalarctos maritimus*). Our project demonstrated for the first time that bears in hibernation do not eat, drink, urinate, or defecate for as long as four months (Folk *et al.*, 1976; Folk and Nelson 1981). The most northern grizzly bears may actually remain in dens for as long as seven months. The sleeping heart rate of all three species of bears was reduced to one quarter of the summer sleeping heart rate when these animals were in hibernation. The types of records made by use of the Iowa radiocapsule are illustrated in Figures 6-8.

Figure 9 is a drawing of a black bear in hibernation, copied from the screen of a closed-circuit television. Four daily observations were made over four months, during which the bear was never observed to leave its curled up position.

This is a good opportunity to point out that much still needs to be done. The information just presented has already been applied in medical clinics but there is an area that would contribute even more. We do not know enough about how much bears move about during the hibernation period. We suspect that at least for a month and perhaps much longer they remain



Fig. 2. Large Iowa radiocapsule, capable of broadcasting for two years.



Fig. 3. Small Iowa radiocapsule, capable of broadcasting up to one year.

curled up with nose near the tail moving very little or not at all. This movement could easily be measured and described either in the field or in laboratory circumstances. One need only attach a small accelerometer to the head of the bear. Think of the application of this phenomenon to clinical medicine, especially in the area of the effects of bed rest. What



Fig. 4. Sterile techniques could be used in field surgery to implant radiocapsules, in this case a hoary marmot, *marmota caligata broweri*. We saw no evidence that any animals implanted with these capsules were aware of the capsule sutured into their body cavity.



Fig. 5. Black bear being implanted with a radiocapsule.

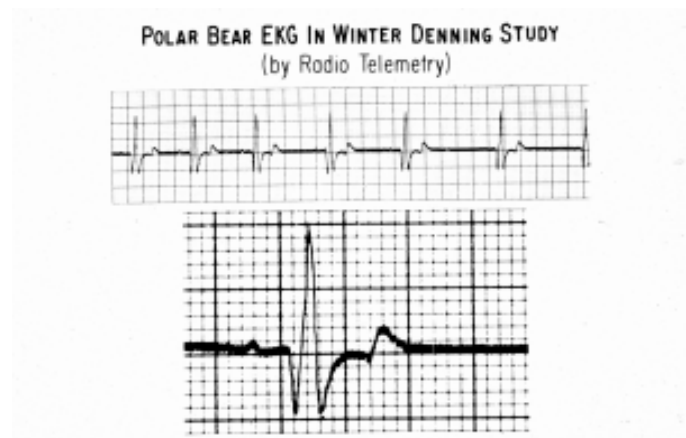


Fig. 6. Heart rate and EKG of a polar bear. Such records were programmed to be recorded automatically at 15-minute intervals for periods exceeding 2 months.

modification of body chemistry permits a large animal to remain immobile for perhaps as long as one or several months? The application to hospital information is obvious.

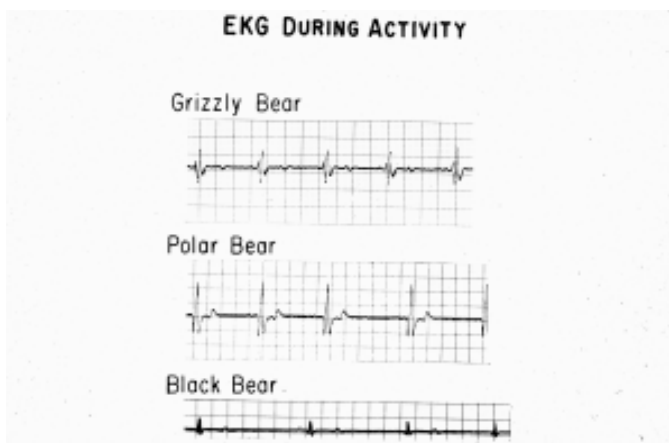


Fig. 7. Programmed records of three species of bears.

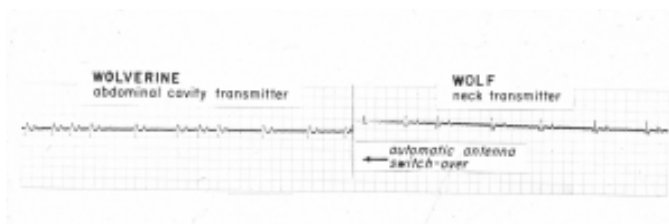


Fig. 8. Automatic switchover from the transmitter in one species of instrumented mammal to another transmitter in another species.



Fig. 9. Drawing of a black bear in hibernation drawn from the screen of a closed-circuit television receiver. Four observations of the bear were made daily for a period of four months.

The field of radiotelemetry has advanced greatly since we made our first capsule in 1957, and field-tested it at NARL. That first model would only measure the heart rate of the animal. Recently, by contrast, we routinely used small radiocapsules in the abdominal cavities of rats to telemeter body temperature, heart rate, blood pressure, and locomotor activity (Folk et al., 1995).

THE DISCOVERY OF OMEGA-3 FATTY ACIDS

We must at this point turn the clock back to one of the first scientists to work in the Arctic, Dr. Vilhjalmur Stefánsson. It will become apparent later what an important influence he had on experiments on large mammals here at NARL. When Stef was on a long journey well into the Arctic with Iñupiat hunters, they had only very lean caribou to eat. All members of the party became quite ill. At this point another hunter arrived from the coast with seal oil in his supplies. He shared this with the hunting party and within a few days they were cured. Stef realized the significance of the fact that something in the oil acted as a vitamin; several years later he conducted a number of prolonged hospital studies to come out with the proof of the need for Omega-3 Fatty Acids in the diet (Folk 1984). The contribution by Iñupiat was obvious. Stef lived with these Iñupiat teachers for five years, gleaned their information and recording it in numerous books for American science.

MODERN INVESTIGATIONS OF OMEGA-3 FATTY ACIDS

The following experiments on polar bears are concerned with Omega-3 fatty acids. The project again underscores the contributions by Iñupiat to research. In the first place, our advisors from the village said that they had observed free-living polar bears on the ice nibbling off the blubber of seals and leaving the protein. This blubber is restricted to the subcutaneous area surrounding most of the seal's body (Fig. 10). Bears in the wild can expect to obtain another seal and thus get more blubber to eat. Information from our Iñupiat advisors started the entire project. When we began the project, the polar bears had to be fed on freshly killed seals; once again we totally depended on the Iñupiat hunters. We will now go into the details of an experiment on polar bears, which led to information showing the importance of Omega-3 fatty acids and the importance of these fatty acids in the food chain in the Arctic Ocean.

To evaluate the differences between nearly 100 percent fat diets and protein diets in polar bears, we carried out the following experiment. To represent fully fed bears, two captive polar bears, a 450-kg male and a 205-kg female were maintained near their natural environment at NARL. The male had been raised at the laboratory since it was brought in as a cub some four years earlier. The female had been immobilized on the pack ice near Point Barrow four months earlier, brought to the laboratory, and maintained in a separate



Fig. 10. Cross-section of a whole frozen seal carcass, showing the layer of subcutaneous fat (blubber) restricted to this subdermal layer over most of the seal's body. Photo by Bruce Ehrenhaft.

cage. For two months prior to sampling, both bears were fed whole seal (*Phoca richardii*) carcasses. Both bears limited their consumption almost exclusively to blubber portions, leaving most remaining portions of each carcass. Because bears would wait three or four days before consuming the muscle portions, seal carcasses were provided to the bears more frequently, to minimize their protein consumption. Blood samples were collected while animals were immobilized with phencyclidine hydrochloride. Blood was drawn into tubes and immediately centrifuged for ten minutes at 600 rpm. The plasma was transported by air from Point Barrow to Iowa City, Iowa with the temperature of the plasma maintained at 4°C. Serum chemistries were analyzed at the Department of Biochemistry, University of Iowa, Iowa City, Iowa.

We used another source of bears to represent fasted bears, because the previous two bears could not be fasted for comparison. At the beginning of October 1991, two bears captured in the city of Churchill, Manitoba were designated as experimental subjects. The bears had walked freely from southern Hudson Bay. One was a four year-old male weighing 176 kg, and the other was a nine year-old female weighing 124 kg. We can presume that these two bears had fasted at least one month and probably longer prior to capture. Although we requested that the Manitoba Wildlife Branch monitor the coast for dead whales or seals upon which these animals could feed, none were found. In addition, neither bear produced feces during the one month of confinement prior to our sampling. The two captured bears were confined within a holding facility designed to deal with bears that caused problems in the city of Churchill. Because these free-ranging bears normally fast all summer, these two confined

bears were not fed. On 6 November 1991, the two bears were immobilized with phencyclidine hydrochloride for relocation by helicopter north of Fort Prince of Wales in Northwest Territories. Blood samples were collected during immobilization. Collection, handling, transport, and analysis of samples were similar to protocols used for the samples collected from fed bears. During transport from Churchill to Iowa City, the samples were maintained at 4°C.

Results from the two fed bears have been published (Kaduce *et al.* 1981). The preliminary results for plasma lipids from fed and fasted bears are presented here for the first time. Plasma from polar bears fed 100% fat diet contained more lipid than in humans, reaching a triglycerides level of $199 \text{ mg/dl} \pm 15 \text{ SE}$ and total cholesterol level of $298 \text{ mg/dl} \pm 24 \text{ SE}$. These levels would be fatal for dogs or laboratory rabbits (Kaduce *et al.* 1981). Yet lipid was higher still in fasted bears as indicated by a triglycerides level of 292 mg/dl and a cholesterol level of $381 \text{ mg/dl} \pm 36 \text{ SE}$ in fasted bears (see Table 1). There were substantial changes in the fatty acid composition of plasma lipids in fed polar bears versus fasted. The Omega-3 fatty acid #20:5 (OFA found in seal fat and fish oil) was considerably higher in the fed state than in the fasted state. Twenty-nine percent of fatty acids in cholesterol of fed bears were OFA in contrast to 3% in cholesterol from fasted bears. Likewise, 13% of fatty acids in triglycerides from fed bears were OFA compared to 4% from fasted bears.

It is a common belief in medicine today that the dietary Omega-3 fatty acids (OFA) reduce the level of saturated fat in human subjects. In our experiment, the most reasonable interpretation is that the known quantity of dietary OFA in seal meat reduces the level of saturated fat in the blood of bears eating nearly 100 percent fat; those bears that had fasted for one to three months were not eating dietary OFA and as in human subjects without this material, the level of saturated fat in their blood was increased.

WHERE DOES THE POLAR BEAR OBTAIN OFA?

For a polar bear, it is important to obtain these necessary OFA. The biology of the food chain for the polar bear is as follows: there are abundant microorganisms and small swimming planktonic animals in the Arctic Ocean because carbon dioxide and oxygen are more soluble in cold water than in warm. Phytoplankton make use of the carbon dioxide for photosynthesis and therefore are found in great

Table 1. Comparison of blood lipid levels (mg / dl \pm SE) between two polar bears eating nearly 100 percent fat, and two polar bears observed to have fasted at least one month, but more probably three months or more.

Polar Bears		
	Fed	Fasted
Cholesterol	298 \pm 24	381 \pm 36 SE*
Triglycerides	199 \pm 15	292 \pm 7
*Standard Error of the Determination		

abundance. Ten times more of this phytoplankton exists in cold water than in the warm waters of the temperate and tropical zones. The single-celled plants (phytoplankton) form small droplets of fat termed "essential fatty acids," so-called because man and the other mammals require these compounds in the manner of essential vitamins (which, because they are not synthesized in the mammalian body, must be consumed in food). Small crustaceans (krill) and fish eat the phytoplankton, and larger fish, seals and whales eat the crustaceans (shrimp) and thus obtain the essential fatty acids originally stored by the phytoplankton. Polar bears are also in this food chain because they eat seal flesh almost without exception. The most important of these essential vitamin-like materials are the OFA.

In more detail, here is the content of OFA in krill. Krill eat the phytoplankton, which is composed of 10 percent fat, of which 34 percent represents one Omega-3 fatty acid. Krill is made up of 17 percent fat, of which 15 percent is OFA. As stated above, polar bears obtain OFA by consuming seals.

The base of this Arctic food chain is easily characterized at Point Barrow. There, it is possible to wade into some parts of the Arctic Ocean and lift a gallon jar of ocean water which contains myriads of small shrimps (krill) and phytoplankton; it is impossible to see through the mass of organic material. We know that there must be great masses of this arctic krill because of the numerous Arctic baleen whales that lived on this krill in the past, and the substantial populations continuing to live on it now (Albert, this volume).

Man as a species is usually at the top of the food chain. By harvesting many tons of krill annually, humans are moving down the food chain to an alarming extent—at least to the extent that marine mammals should be alarmed. Six nations are harvesting krill off Antarctica. By contrast, harvesting krill directly in the Arctic fortunately remains impractical because of the unreliability of open water for commercial harvesting operations.

CONCLUSIONS

In order to account for the significance of OFA results to clinical medicine it is necessary to understand that there is a clinical debate on implications. One school of thought advocates using the OFA in the form of fish oil to lower cholesterol in human subjects. Another school of thought takes the attitude that because there are some side effects of fish oil it should not be used. The people in the latter school of thought recommend that individuals who apparently need OFA should simply eat freshly cooked fish three times a week. The first school of thought interprets our results on polar bears as further evidence that the OFA do lower cholesterol levels in mammalian blood.

There is, in any case, a biochemical advantage for cold weather Native populations who have sea mammals (seals and whales) and marine fish as part of their diet. Because they are protected by the Omega-3 fatty acids in the flesh of these sea mammals, these circumpolar residents have low incidence of cardiovascular disease (Bjerregaard and Young 1998). They are probably protected against a buildup of cholesterol in the same way as the polar bears in the above experiment. We have recently estimated that at least 208 000 cold-weather residents in the circumarctic region are protected by the consumption of the omega-3 fatty acids originating at the base of the food chain in marine phytoplankton (Folk et al., 1998: 444).

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Large Mammal Energetics at NARL

Robert E. Henshaw¹

ABSTRACT: Metabolic, insulative, and vasomotor adaptations in large-bodied arctic mammals formed the topics for continuing studies in physiology and energetics at NARL's Animal Research Facility in the 1960s and '70s. Examples of results are illustrated and discussed.

Key Words: Energetics, vasomotor control, peripheral circulation, cussedness, insulation, heat exchange, heat flow, heat conservation, blood viscosity, homing,

INTRODUCTION

NARL was an ideal facility for physiologists and biochemists interested in adaptations of large arctic animals. For logistical and legal reasons their studies were then, and still are today, virtually impossible to conduct at any other facility in the world. The key attribute was the Animal Research Facility (ARF) maintained by Pete Sovalik and his Inupiat staff (Philo et al., this volume). The ARF provided several dozen wolves (*Canis lupus*), a dozen arctic foxes (*Alopex lagopus*), nearly a dozen wolverines (*Gulo luscus*), nearly a dozen snowy owls (*Nyctea scandiaca*), several marmots (*Marmota broweri*) and arctic ground squirrels (*Citellus parryi*), two polar bears (*Ursus maritimus*), two porcupines (*Erethizon dorsatum*), two ravens (*Corvus corax*), a grizzly bear (*U. horribilis*), a seal (*Phoca* sp.), and numerous weasels and lemmings. All but the small species were caged out of doors year around, and so were fully acclimatized to prevailing conditions. The bears' cage was in an unheated building to prevent accidents. The animals could be immobilized (see Folk, this volume) and anaesthetized, and thus could be studied under controlled conditions. Pete Sovalik provided essential natural history information and counseled researchers on the species they studied (Henshaw and Brewer, this volume; Brewer and Schindler, this volume).

My own studies from 1966 through 1975 focused on mechanisms of heat exchange and heat conservation in the wolf and the wolverine that evolved in the temperate zone and in the arctic fox that evolved in the arctic. We also studied sled dogs, caribou, and a seal. Below I describe those observations that were then new or unique. Several of our conclusions reversed conventional knowledge, which then was largely based

on temperate and subtropical species in moderate climates.

METHODS

We analyzed heat exchange in large animals using Newton's Law of Cooling:

$$HL = SA (T_s - T_a) / \text{Insulation}$$

This law states that heat loss from any surface area of the animal is equal to the temperature difference between the skin and the air (the gradient or driving force) divided by the insulation (the resistance to heat flow). In terrestrial mammals, nearly all of the insulation is due to fur. Since heat may be lost by convection, conduction, and radiation, complicating Newton's Law, we attempted to measure each route of heat loss separately while holding the others constant. Working in a walk-in freezer in the Old Lab, in our lab associated with the ARF, and outside of the door of our lab, we studied the animals at -25° , 0° , and $+20^{\circ}$ C both summer and winter (Figs. 1 & 2). All measurements in those days were made with analog instruments and data calculated by hand. We used heat flow transducers to measure directly heat flowing, thermistors to measure skin and deep tissue temperatures, an infrared thermometer to measure radiant temperature, and fur depth as an index of insulation. By combining data from up to 42 sites on each animal the total heat lost by the animal could be quantified.

SELECTED RESULTS

Seasonal Insulative Advantage: We found that the wolf and the arctic fox add so much fur and underfur in the winter, that they are actually better insulated in the winter at an air temperature of -25° than they are in the summer at an air temperature of 0° C (Table 1). The extremely thick and dense winter coat of the arctic

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Fig. 1. Tim Casey, undergraduate assistant, carries an anaesthetized wolf to the Lab in a manner not fully authorized by Lab Director, Max C. Brewer.



Fig. 2. Larry Underwood, then a graduate assistant, using a thermistor to measure skin temperatures in an anaesthetized wolf outdoors. Wire leads to a recorder indoors in the lab in the background.

fox is well known. The wolf during the winter also develops dense underfur which becomes matted around the guard hairs holding them in a continually erect position. In both of these species in the winter, piloerection is virtually impossible as a means of increasing insulative protection on the trunk and upper appendages. In contrast, the wolverine develops less winter underfur, which does not become matted. Even gentle breezes can part the hair on the wolverine's back down to the skin. Consequently the wolverine loses heat somewhat more rapidly to still air in the winter, and might lose heat very rapidly on windy winter days. We concluded that the wolverine survives in arctic cold by a combination of limiting its exposure, and the species' renowned sheer cussedness.

Quantification of the continuous heat-conserving quality of the extremely high insulation on the trunk of arctic mammals lead us to the more interesting conclusion that it also restricts the animal's capacity to dissipate surplus heat generated during exercise. It

was clear that the primary routes of heat loss had to be the animal's belly and legs, which are exposed during activity. Our later studies of energy conservation would have to quantify the heat loss concomitants of activity.

Heat loss from feet: As we turned our attention to how these species dissipate heat from their feet we grew interested also in how they protect their feet from freezing. The footpad of the wolf is naked year around, whereas the feet of the wolverine and the arctic fox are thinly furred in the winter. Clearly, circulation of warmed blood to these peripheral parts was implicated. Simply applying a tourniquet to the leg of a wolf in the cold confirmed the hypothesis that arctic animals protect their feet from freezing with warmed blood.

Working with anaesthetized animals in the laboratory, with one foot submerged in a bath of antifreeze cooled to -38°C (Fig. 3), we demonstrated that all three species maintain their foot pad temperature above the tissue freezing temperature (near -1°C) by pumping as much blood through the foot pads as necessary (Henshaw, Underwood, and Casey, 1972). In the wolf we directly measured heat delivery rates to the hind foot at least as high as 25% of the animal's resting metabolic rate; heat loss from the wolf's front foot would be even greater because of the larger surface area.

At the time we began our studies of peripheral circulation, textbook physiological wisdom held that mammals in the cold conserve heat by reducing flow of warmed blood to the appendages. This reduction permits the appendages to cool while holding body heat in the trunk. Much of the detailed work at that



Fig. 3. Lightly anaesthetized wolf in foreground, with one foot in -38°C bath, three remaining feet equipped with transducers. Author at recorder in background.

Table 1. Seasonal Insulative Advantage (SIA) ¹

	Mean $\Delta (T_s - T_A)^2$ (%)	Mean Δ Fur Depth ³ (%)	SIA \pm Std. Error	Winter T_A at which SIA = 1
WOLF (n = 30)				
Trunk	61	126	2.06 ± 0.26	-49 °
Proximal appendages	65	150	2.31 ± 0.71	-59 °
Distal appendages	52	88	1.70 ± 0.53	-44 °
Dorsum of feet	46	66	1.43 ± 0.53	-36 °
Tail	46	24	0.52 ± 0.16	-23 °
Nose	120	0	0.01 ± 0.004	0 °
Foot pads	33 to 2900	0	0.03 ± 0.006	0 ° to -27 °
WOLVERINE (n = 9)				
Trunk	82	117	1.43 ± 0.26	-33 °
Proximal appendages	83	228	2.68 ± 0.38	-77 °
Distal appendages	79	142	1.80 ± 0.30	-49 °
Dorsum of feet	77	100	1.30 ± 0.30	-36 °
Tail	61	222	3.64 ± 0.79	-80 °
Nose	79	33	0.64 ± 0.56	-17 °
Foot pads	109 to 2900	3000	1.03 ± 1.45 to 30 ± 42	-30 ° to ca. 0 °

$$1. \text{SIA} = 1 / \Delta \text{HL} = \Delta \text{Fur Depth (\%)} \div \Delta (T_s - T_A) (\%)$$

Thus: SIA <1 = decreased effective insulation in winter with respect to summer
 SIA >1 = increased effective insulation in winter with respect to summer

$$2: \text{Winter } (T_s - T_A) \div \text{Summer } (T_s - T_A)$$

$$3: \text{Winter Fur Depth} \div \text{Summer Fur Depth}$$

time had concerned man and other species that evolved in subtropical or temperate climates. Few studies described arctic-adapted or acclimatized species in chronic cold. I was convinced that such heat conserving mechanisms, while helpful in mild climates, would be maladaptive in the continuous cold of arctic winter. In fact, as a price to pay for virtually naked feet and agility, the animal must enhance, not restrict, blood flow to the exposed parts. Textbooks at the time took note of, but did not explain, that at high energy cost, the hands and feet of the Inupiat are maintained as warm as their trunk. Some of the original work by Per Scholander and Laurence Irving at ARL did record that arctic species may have “cold feet.”

Our studies confirmed that large wild species acclimatized or adapted to extreme cold do not waste precious body heat maintaining the feet at a warm temperature the way humans and other tropical species do. Rather these species achieve maximum energetic efficiency by maintaining their feet continuously at

about +1° C. The wolf is not born with this capability. Evolutionarily adapted to temperate environments, it must perfect this “peripheral thermoregulation” during its first year of life. Wolf puppies, like humans, show cyclic waves of vasodilatation (“Lewis Waves”) when exposed to cold, but these waves subside by the age of 6 months, although precise regulation of the foot temperature near +1° C is not perfected until the age of 2 years.

The arctic fox regulates its foot temperature as well as the wolf does. The wolverine does not. While searching for the reason, we noted that during the winter the wolverine develops a thick pad of long hairs growing from the base of the paw pads and extending out past the tips of the toes. We concluded the wolverine relies on this hair pad to reduce heat loss when walking on cold surfaces during the winter, and thus it relies less on circulation of body-warmed blood to protect its foot pads from freezing than do the two canids. We were the first to interpret the function of

the stiff vibrissae surrounding each toe pad as important to holding the long hair pad in place while walking.

Mechanism of Peripheral Thermoregulation:

How could so much blood perfuse foot tissue at $+1^{\circ}\text{C}$? We measured the viscosity of wolf and wolverine whole blood and found that, like human blood, it becomes viscous at low temperatures. The increase in viscosity suggested that either the blood plasma is separated from red blood cells and carries heat to cold foot pad tissues, or (more likely) the blood vessels were somehow specialized to facilitate blood flow at low temperatures in response to heat demand of the cold surface walked on. We confirmed the latter hypothesis by infiltrating liquid plastic into the feet of wolves that had died of other causes. The plastic castings (Fig. 4) demonstrated for the first time an extensive vascular complex confined mainly within the skin surface of the foot and toe pads; the spongy tissue in the center of the pad lacks all but a few blood vessels. With the cutaneous network located in the surface with the highest heat demand, its perfusion with warmed blood could prevent freezing in the rest of the foot and toes (Henshaw, 1978). Microscopic examination of these castings revealed a massive arteriovenous plexus in the subcutaneous tissue, which could carry large amounts of blood with little resistance (Fig. 5A). A fine capillary network extends out from this plexus into the cutaneous tissue to provide nutrient flow (Fig. 5B). The A-V plexus appeared to have structures that might regulate blood flow through the footpad.

When we attempted to explain the functional control of this plexus using injected vasoactive drugs, we found that it is very sensitive to vasodilators, and



Fig. 4. Plastic casting of vessels in the front foot of an adult wolf. Note the absence of vessels in the footpads. Thoroughfare artery delivers blood to the center of the cutaneous plexus, while veins return it from the periphery.

uniquely insensitive to vasoconstrictors (Henshaw, 1984). We could induce a rise of 30°C in the wolf's foot for an hour or more while the foot was in the -38°C bath, but we could not induce cooling below about -1°C before physiologically induced vasodilation filled the foot with warmed blood.

Before our work ended, we believed that we could generalize that warm bodied wild animals in chronic extreme cold maintain maximum energetic efficiency by keeping their feet continuously near $+1^{\circ}\text{C}$, and that they are capable of furnishing sufficient heat via the circulation of trunk-warmed blood to protect the feet from freezing, regardless of the heat demand of the surface, even if this represents a high energy cost. Although food energy is often in limited supply in the arctic, animals do not exhibit frost bitten toes due to restriction of warmed blood. In contrast to wild species, most humans do not significantly augment peripheral circulation, so that our hands and feet cool, and eventually freeze. Sensation and motor control are lost when hand or foot temperature go below about 15°C . The Inupiat, however, are known to maintain their hands and feet well above 15°C with large circulation of warm blood, even though this circulation exacts a high energy cost.

A visiting dignitary being shown through the ARF by Pete Sovalik stopped to ask why we were studying the temperature and circulation of feet of these wild animals. When I answered him with a question of my own about what his first and strongest impression was on meeting Pete Sovalik, he volunteered that it was Pete's very warm hands. I answered, "Exactly!"

One other study demonstrated NARL's unique capability to support animal studies, which would have been nearly impossible elsewhere. The Arctic Institute of North America awarded us a grant for \$700 plus NARL logistical support to study homing ability in the wolf. Five of the wolves from the animal colony at NARL were immobilized, then flown completely anaesthetized, in the NARL airplane to Umiat nearly 300 km (200 miles) to the southeast, and transferred by motor boat to the south shore of the Colville River. Over the next seven months movements of these wolves were followed. Three moved toward Barrow, and one returned to NARL and reentered her cage after 120 days (Henshaw and Stephenson, 1974). Pete Sovalik suggested the wolves might have homed on the noise of airplane traffic to and from NARL. No one has offered a more plausible explanation for the animal's ability to home this distance without prior knowledge of the territory, and even in the absence of

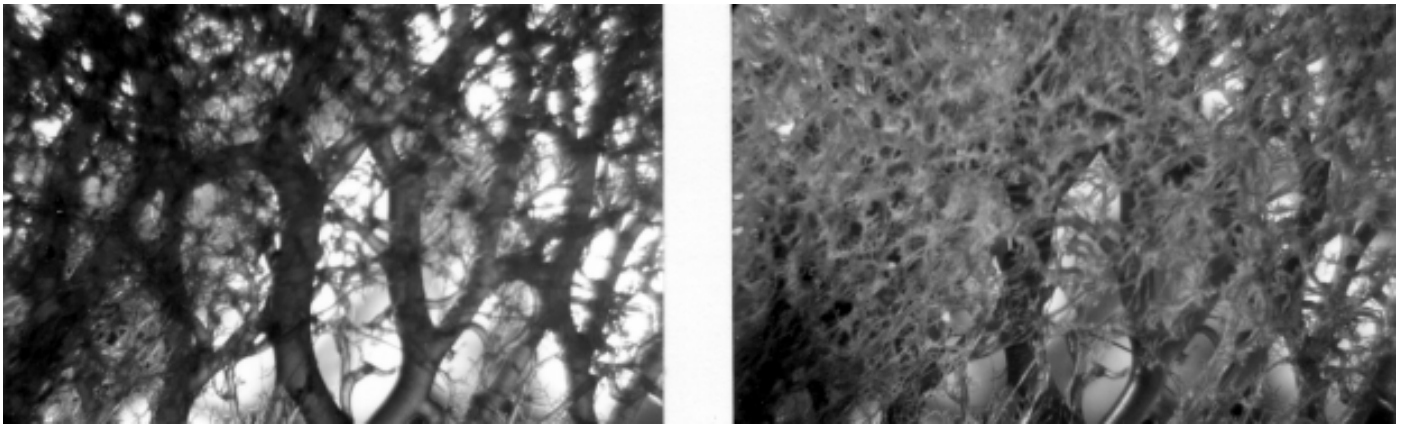


Fig. 5a. (left). Cutaneous vascular plexus, backlit, to show massive arteriovenous plexus. Fig. 5a. (right) Same field as Fig. 5a, frontlit to show fine capillaries arising from the A-V plexus.

daylight toward the end. Where else could a grant for \$700 plus logistical support have provided five large animals, air transport, a week of field logistics and air surveillance, and seven months of liaison throughout the North Slope?

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Anthropological Research Supported by the Naval Arctic Research Laboratory

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ABSTRACT: The Laboratory at Barrow was instrumental in facilitating anthropological research at a number of sites in northern Alaska, subsequent to its founding in 1947. Enthusiastic support and involvement in the work by members of North Slope communities also aided arctic anthropologists in overcoming the logistics costs and challenges involved in their work, a tradition that has continued to the present day.

Key words: Iñupiat prehistory, Clovis, Folsom, Thule, Birnirk, Denbigh Flint Complex, genealogy, Point Franklin Project, Nunamiut Iñupiat, Arctic Small Tool Tradition, Ukkuqsi, Utqiagvik, Walakpa

During the period between its inception as the Arctic Research Laboratory in 1947 and the decommissioning of the Naval Arctic Research Laboratory, it is difficult to find examples of anthropological research on Alaska's North Slope that were not assisted in some way by the laboratory. The high cost of arctic logistics and the traditionally meager funding for social science research made the presence of the laboratory and support by the Office of Naval Research key factors in the development of our present state of knowledge of northern Alaskan anthropology.

The earliest anthropological research was conducted in concert with petroleum exploration in PET-4, particularly in conjunction with geological field parties. In the summer of 1947 Edward G. Sable, a geologist, found a fluted projectile point on a ridge later known as Folsom Point Syncline in the Utukok River drainage (Thompson 1948). The find was pronounced a Folsom point by the leading Paleo-Indian expert of the day, Frank H. H. Roberts, and it seemed to confirm the hypothesis that the earliest Native Americans, those of the Clovis and Folsom cultures of midcontinental North America, had passed through Alaska on their way from Asia to the New World. This discovery led to more formalized archaeological survey.

Before the 1949 field season, Ralph S. Solecki briefed U.S.G.S. field parties on the kinds of cultural materials they might encounter on their traverses, and himself accompanied a field party, which explored the Kukpowruk and Kokolik rivers just west of the Utukok (Solecki 1950; 1996). Solecki recorded a number of archaeological sites in these surveys and provided a preliminary summary of the archaeology of the region (Solecki 1951a). The 1950 field season yielded two

additional fluted points, this time found just south of the crest of the Brooks Range on the Kuguruk River by U.S.G.S. geologist Milton C. Lackenbruch (Solecki 1951b). The same summer at Natvakruak Lake north of Anaktuvuk Pass Robert J. Hackman, accompanying another field party, located a fluted point in a site consisting mostly of materials attributed to the Denbigh Flint Complex (Solecki and Hackman 1951). In the Barrow area, Wilbert K. Carter commenced excavations at the Birnirk site at the base of the Barrow spit, expanding upon work started earlier by Ford (Rye 1950) to elucidate the origins and nature of the Birnirk culture (Carter n.d., Ford 1959).

John M. Campbell's pioneering research in the central Brooks Range, which began 1956, received support from the Arctic Research Laboratory. Campbell's archaeological work spanned the entire range of human occupation, from the present Nunamiut Iñupiat, among whom he lived, to the earliest cultures of the area, allowing him to formulate the first cultural sequence for the region (Campbell 1959; 1961a; b; 1962a; b; 1968). Campbell's theoretical approach made extensive use of ethnographic data provided by Nunamiut informants as well as archaeological data. Campbell also introduced two other influential anthropologists to the Brooks Range, Edwin S. Hall, Jr., and Nicholas Gubser. Gubser's senior thesis at Yale University, published as *The Nunamiut Eskimos: Hunters of Caribou* (Gubser 1965), provided an ethnography of the people of Anaktuvuk Pass. Edwin S. Hall, Jr., began his northern anthropological work in the summer of 1959 when he assisted Campbell in the excavation of the Kayuk site at Anaktuvuk Pass. Later, Hall conducted a number of archaeological projects in the Brooks Range, including extensive work in the Noatak drainage and at the Sikoruk site at Tukuto Lake (Hall 1971; 1976). Much of Hall's work was accomplished

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with the assistance of the ARL and the Office of Naval Research.

In 1960, as part of a paleontological project led by Otto Geist and supported by the ARL, Thomas D. Hamilton excavated a late-prehistoric Eskimo house near Atqasuk on the Meade River (Hamilton n.d.). In 1961, the ARL provided logistics support to a Columbia University expedition led by Ralph S. Solecki, which conducted archaeological surveys and discovered 19 sites in the vicinity of Peters and Schrader Lakes and in the Franklin Bluffs region along the Sagavanirktok River (Solecki et al. 1973).

William M. Irving conducted several archaeological surveys in arctic Alaska and key excavations at Punyik Point on Etivlik Lake, which resulted in the definition of the Arctic Small Tool Tradition, an archaeological manifestation that extends from Alaska to Greenland (Irving 1962; 1964; 1970). In 1965 and 1966, Robert L. Humphrey, Jr., revisited the sites on the Utukok River, finding additional fluted point material which he assigned to his Driftwood Creek complex, the earliest period in his cultural chronology for the arctic slope (Humphrey 1966; 1970). Shortly thereafter, Dennis J. Stanford began his work on Thule culture origins at Walakpa on the Chukchi Sea coast (Stanford 1972; 1976).

In the late 1970s, NARL provided logistics support to government agencies involved in the second phase of petroleum exploration in the petroleum reserve, by then named the National Petroleum Reserve - Alaska. In 1975, the Bureau of Land Management assumed surface management responsibilities in the reserve, including responsibility for protection and inventory of cultural resources. NARL provided the initial support for archaeological reconnaissance beginning in the summer of 1976.

NARL also commissioned important research. Edna MacLean, now President of Ilisagvik College, collected genealogical information during her summers of work in 1968, 1970 and 1970. Native Iñupiat Eskimo residents' involvement in research activities has continued to pay dividends to the community.

Cultural investigations by individuals such as Ernest S. "Tiger" Burch, Jr., and Robert Spencer have been facilitated by the generally receptive attitude toward research on the North Slope that NARL helped to foster. That enthusiasm also is reflected in the important coastal studies carried out after NARL's closing by the Utqiagvik Archaeology Project in the early 1980s

(Hall 1990), the Point Franklin Project (Sheehan 1997), and with the little frozen girl of Ukkuqsi, whose scientific recovery was mandated by the Elders of Barrow (Jensen n.d.).

From its beginnings in 1947 NARL provided key logistics support for more than three decades of anthropological investigations in arctic Alaska. Without such a resource available to early researchers, the tremendous expense of arctic logistics would have precluded many of the studies, and our current understanding of northern prehistory and Native cultural history would be considerably diminished.

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Explorations of the North Slope's Ecological Diversity

John J. Koranda¹

ABSTRACT: In adventures and mis-adventures spanning a quarter-century, the author explored lakes, rivers, geological formations, and plant communities across Alaska's North Slope with the support of ARL and NARL. The author shares highlights, images, and key references from these fondly remembered years.

Key Words: Arctic transects, *Aufeis*, ecological diversity, Lisburne (Cretaceous) Formation, Murphy's Law, pingos, plant ecology

In early May of 1952 I first set foot on the Arctic Coastal Plain and spent six months at the old ARL Lab studying lake chemistry and limnology in the Barrow area with Prof. G. W. Prescott from Michigan State University. We analyzed the chemistry and biology of Fresh Water Lake (just south of ARL) in the summer of 1952 (Prescott and Vinyard, 1965) as well as a dozen other lakes in the Barrow area. When I used an ice corer to obtain a water sample in May from Fresh Water Lake, there was hardly any water in the lake—it was almost all ice—but from under the ice I managed to get a couple hundred milliliters of soupy liquid that defied analysis. My courses in Limnology had not prepared me to deal with that type of sample. I had to put two extensions on the ice auger (Fig. 1) to get to the bottom of the ice, and when I got to that depth, there wasn't room for a standard water-sampling bottle. So I had to invent a sampler and pull the stopper on it when it was under the ice. This was the first of many adaptations of standard methods that we had to improvise for working in this extreme environment. When we left Barrow in December there was almost a metre (3 feet) of new ice on the lake. The abundant copepod in Fresh Water Lake, *Limnocalanus*, did not form egg sacs until ice thickness reached about 65 cm (Comita 1956).

In 1953, I assisted Dan Thompson in his research on lemming populations in the Barrow area (Thompson, 1955). I remember that 1953 was a high lemming year, because as part of my work I sat atop a 10-foot stepladder on the tundra, making observations on the numerous rodents moving in a prescribed area. I took a bit of ribbing for my “lofty” position on the tundra, but was able to assess activity levels of the rodents in a large area. It seemed that there were a dozen of them moving around at any given time. Lemmings scurried down the streets of Camp in this “high” year. Frank



Fig. 1. The author on Freshwater Lake in May 1952, with specially extended ice auger to bore through ice to the small reservoir of unfrozen water, as described in the text.

Pitelka and I drove a “weasel” to the Inaru River on the winter tractor trail to the Meade River early that summer, to see if the lemming high extended that far inland. As we turned around at the Inaru River to head back to Barrow, the track on the weasel broke (Fig. 2). We packed up our gear and had hiked for about 10 hours when an Eskimo with a dog team and a sled full of ducks, appeared on the southern horizon. We talked him into giving us a ride, and were soon on the outskirts of Barrow. When the dogs smelled the village and home, they went into high gear. The only way we could get off was to roll off the sled into the muddy snow on the edge of town. Two Eskimo boys gave us a hand for our wild dismount.

Over the next six years I collected plants and made ecological observations along six major rivers on the North Slope from the Pitmegea River at Cape Sabine on the western end of the North Slope, to the

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Fig. 2. Another instance of Frank Pitelka's 'weasel,' having shed a track the evening before, here within sight of home base (NARL Building # 360 visible, right rear, beyond Top of the World Bridge). May 1969 photo by Dave Norton.

Sagavanirktok River, east of the Colville River, and on the east to the Firth River on the Canadian border. There were many adventures associated with fieldwork in this interesting remote area, which earlier had seen exploration parties of drillers identifying the oil resources of the Petroleum Reserve No. 4 (Schindler, this volume). In 1973, I described and illustrated many of the features discussed here, in the inaugural issue of the journal *Alaska Geographic* (Koranda, 1973).

The field trips along the North Slope's consequent rivers ("consequent" means simply flowing downhill, hydrologists' term describing rivers that follow topography for the shortest general routes to emptying into the sea) provided excellent transects of the Arctic Coastal Plain. Max Brewer, Lab Director in those years, always made sure we were well provisioned on these trips, often inspecting our gear before we left Barrow. He would often add another can of pancake flour to our food supply. He once suggested that we take ice skates along, in case the ARL plane didn't come to get us, so that we could skate back to Barrow when freezeup occurred. Our many river trips were carried out by flying in to an upstream site and landing

on a bar of sand or gravel, or on a lake, then travelling down the river by canvas-covered foldboat (Fig. 3). Our camping equipment was carried in two of these 18-foot boats with two men in each one, and our navigation was usually by 9 × 9-inch Navy aerial photographs. Conventional topographic maps were useless, but we could find the working channel of the highly braided rivers on the aerial photos, and we seldom went wrong with them. We carried some ancient, military C- and D-rations (which were mostly edible) and had the Camp Mess Hall make up large cans of supplemental food. When we reached the Arctic Ocean coast, we waited until an ARL plane picked us up, and returned us to Barrow for a good meal. The collections of plants and ecological observations that we made on these transects of the North Slope tundra were unique, because most earlier work had been confined to coastal locations.



Fig. 3. Canvas foldboats used in author's transects by river over several years of exploring the diversity of Alaska's North Slope.

Our first river trip was on the Toolik River, and started just upstream (south) of the White Hills. Their light-colored gravel domes contrasted with the dark surrounding tundra, hence their name. I went in on the first flight with the tent and the camp stove with pilot, Andy Anderson. We made a wild landing on a bend of the river, because the wing almost caught the cut bank of the river. I expected the professors who followed us to get a thrill out of their landing, but Andy landed on a nearby lake, so we packed the rest of the field equipment to the river. We were refining our river trip methods on this maiden voyage but managed nevertheless to make some excellent collections and observations.

We measured and described the vegetation on a large pingo just northwest of the White Hills. Any temptation

to feel like intrepid explorers evaporated upon climbing to the top of the pingo, where we found a USGS benchmark. I collected *Phlox sibiricus* on the top of that pingo (Fig. 4). That plant's presence surprised me because the pingo was surrounded by wet tundra and sedge marshes, which weren't the typical habitat for this plant. Eventually I came to appreciate pingos as islands: the vegetation on them was consistently different from vegetation growing in the surrounding tundra. My botanical colleagues initially scoffed at my idea, because of the small area of each pingo, but this "island pattern" repeated itself at almost every pingo I studied. At the delta of the Toolik River, a system of fairly large dunes was present and provided a new tundra habitat for study. We had been "broken-in" on the tundra in an area of ice-wedge polygons, so these exotic habitats in an arctic setting intrigued us.



Fig. 4. *Phlox sibiricus*, a dry-habitat plant, in flower atop a pingo that is surrounded by moisture-saturated tundra. Pingos began to impress the author as habitat islands, based on observations of anomalous plants such as this one.

We flew south again to the upper Sagavanirktok drainage to a point on the Ivishak River, to begin another trip to the Arctic Ocean. The gravel bars in this part of the drainage basin contained round, cobble-sized stones with marine fossils in them, derived from the erosion of the Lisburne (Cretaceous limestone) Formation upstream. The Franklin Bluffs, with their calcareous sand and gravel exposures, again provided our four-man team with new topographic features and plant life for description. I collected *Erigeron compositus* on the gravel domes of the Franklin Bluffs. This was a new northward extension for the species' known range (Hultén, 1968).

One day, I had perched on the top of a gravel dome where mosquitoes were less abundant, when I heard footfalls behind me. Believing them to signal the approach of one of our crew, I turned to see a large caribou, climbing the dome for the same reasons I had. Later I made a detailed study of the vegetation of the Franklin Bluffs area using 27 × 27-inch enlargements of the Navy aerial photographs (Koranda, 1960). Placing a sheet of transparent acetate over the photograph mounted on plywood, I outlined the vegetation types on the photograph, and made species lists and notations on the acetate. Later I recorded statistical samples of the vegetation in all of the discrete units perceptible on the photographs. This method would probably not be usable in any other vegetation except the low tundra of the area. Our trip on this occasion ended in a small tragedy. We returned to Barrow via Umiat, where all of our equipment and collections were burned in a quonset hut when a stove caught fire. We returned to Barrow in shirtsleeves to tell our sad story to the Director.

Several sites were noteworthy for their interesting topography, plant populations, and endemic landforms. The outcrops in the Pitmegea River valley and adjacent areas supported plant species that reached their eastern circumarctic limits there. The xeric (dry) habitats of the rock outcrops supported many species of lichens and vascular plants not found on the wetter, poorly drained tundra of the northern edge of the Arctic Coastal Plain. I found a saxifrage on these outcrops, *Saxifraga eschscholtzii*, probably named after the ship's doctor on the *Rurik*, a small Russian vessel whose captain, Otto von Kotzebue, piloted the ship into arctic waters in 1815-1816 (Mahr, 1932). I spent two weeks in the Pitmegea River area, collecting plants on the adjacent outcrops and tundra with Henry Childs (1959). In camp, we had been reading an account of an earlier exploration by Diamond Jenness (1995) in the same area, and the strong winds common to the area were mentioned in that book. Within a couple of days, as if on cue, the winds rose and immediately broke all our tent poles, flattening our camp. There was an abundance of driftwood on the beach here, so we dragged 3-4-inch (8-11-cm) trunks to the camp, and wove a ponderous and ridiculous frame over the tent out of these logs to support the canvas. When the ARL pilot came to pick us up, he remarked on this bizarre structure, but we shrugged it off, by assuring him that it was standard procedure in the area.

The bluffs along the lower Colville River's west bank supported populations of nesting predatory birds,

Peregrine Falcons, Rough-legged Hawks and Gyrfalcons, which intrigued the ornithologists—notably Kessel and Cade (1958). The Toolik and Sagavanirktok River valleys contained arctic landforms described by only one or two scientists (Mackay, 1962). The pingos of this area are readily seen from low-flying aircraft and had been measured by USGS geologists who left benchmarks on a few of them. (A GPS instrument, in hindsight, would have been handy then, for precisely placing a landform on the map.) The Tertiary outcrops of the Franklin Bluffs provided another ecological stage for plants and animals, with many alluvial fans, ravines with colorful sand exposures, and patterned ground on the upper domes. Rough-legged Hawks and Peregrine Falcons also nested on those bluffs. Plant fossils in the Franklin Bluffs outcrops indicated that a warmer climate had prevailed here at some time long ago.

On the Canadian border, the presence of *aufeis*, coarse calcareous alluvium, and steep topography, as well as some of the northernmost stands of spruce trees, made the Firth River area an unusual ecological workshop for scientists. *Aufeis* is ice that forms in flowing river channels. It forms downstream of perennial springs or artesian sources of groundwater. Gold miners in subarctic Alaska long ago named these formations “spring glaciers.” Building up all winter, *aufeis* usually extends onto adjacent gravel bars and terraces of the river. Over the next spring and summer the ice may melt, but sometimes persists throughout the summer (Fig. 5). It may attain several metres in thickness, and melts or sublimates slowly in the dry arctic air.



Fig. 5. Firth River *aufeis* field, near the Canada-Alaska border, where spruce (*Picea*) trees venture far north of the Arctic Circle.

On the upper Ikpikpuk River, we discovered several pingos that illustrated the time sequence of development of this endemic arctic landform (Koranda, 1970). The raised slopes of these conical mounds hosted unique assemblages of plant species compared to the poorly drained tundra surrounding them. We found a wonderful mammoth tusk lying on the bank of the Ikpikpuk River (Fig. 6) and struggled to get it up on the tundra for possible pickup by airplane. Animals, such as ground squirrels and hawks, used the pingos for nesting and burrow sites because they were drier than the adjacent saturated, marshy habitats. When we left the area, the pilot banked the plane steeply over the pingo I had measured, and I looked right down the “crater” of the pingo through the lens of the camera

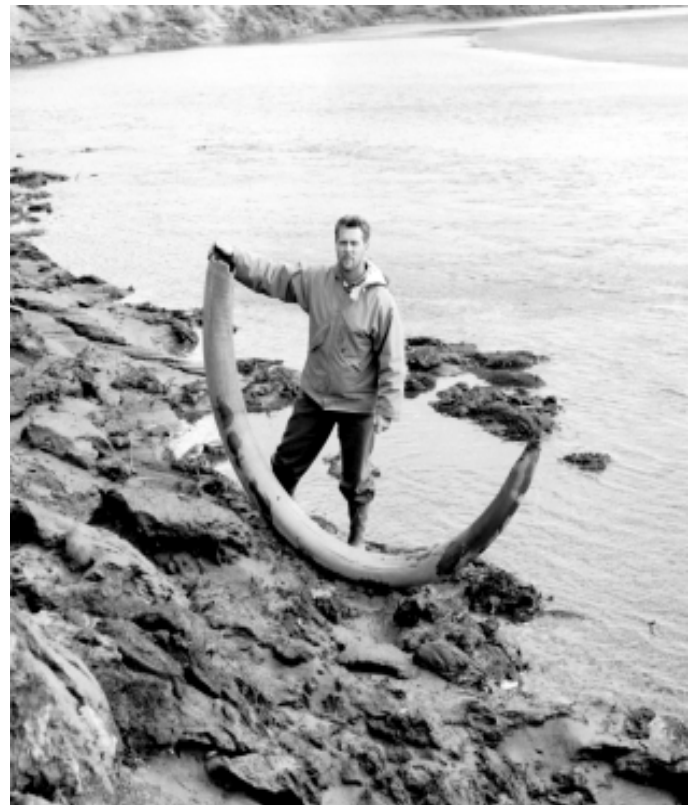


Fig. 6. Pleistocene woolly mammoth tusk, discovered on the Ikpikpuk River by the author's team during one of their river transect surveys of Arctic Slope diversity.

(Fig. 7; Koranda, 1975).

In the Meade River area, near the old coal mine, we found sand dune systems that presented another unique tundra environment for plants and animals. We repeatedly found northward extensions of arctic-alpine plants into arctic Alaska in this area. Arctic loons, jaegers, snowy owls, lemmings, and many shorebirds nested in this relatively balmy area of the North Slope. It was called the “Banana Belt” by ARL scientists who



Fig. 7. Aerial view of the top ("crater") of a pingo on the Ikpikpuk River.

did most of their research in the Barrow vicinity. Emily Ivanov Brown, an Eskimo teacher from Unalakleet, was teaching at the Meade River school the year Frank Pitelka and I went there. She insisted that we have dinner with her, and after dinner she offered us some blueberry wine she had made the previous year. It was rather strong for wine, and, being impressed by its strength, we asked her how she made it. She said the usual way that they teach in the Extension Service course at the University of Alaska, but last winter it froze a little and she took a couple inches of the ice off the top of it. Professor Pitelka and I credited her with cryo-distillation—another example of adapting classroom methods to the Arctic.

I returned to the North Slope and to NARL in the 1970s to conduct some detailed biometeorological studies on the Barrow area vegetation (Koranda et al., 1978), and to make a survey of many of the sites discussed here for nomination as national landmarks to be recognized by the U.S. National Park Service. We recorded 32 parameters of the low-level meteorology and active layers of the soil a couple of miles from NARL in the IBP program. While setting up our equipment, we found that we could not slow it down from recording data at 20-second intervals. (One of the lesser-known corollaries to Murphy's Law holds that the *weirdness* of things to go wrong increases with distance from home.) At that rate, we would use up our tape supply in a few days, so I wired back to California for another footlocker full of tape. When we got back home we had this unexpected, huge amount of data, and were wondering what to do with it. I suggested we run 15 minute averages of the 45 records, and use those. It worked out well, and we produced evapo-

transpirational values for the tundra vegetation that agreed with the data produced by other teams in the area using different methods. Sometimes you win.

I conducted the fieldwork for the U. S. National Park Service Landmarks Program (Koranda and Evans, 1975) with a U.S. Geological Survey geologist, Bob Detterman. We traveled over most of the eastern portion of the North Slope by helicopter (Fig. 8). The ability to set the helicopter down almost any place to observe, and take photographs, was quite satisfying compared to our earlier, hard-fought access to the North Slope tundra in the canvas boats. I was asked to take ground photographs of the old tractor trails created by the Pet-4 exploration trains (Fig. 9). We were told that these trails were evident from space, and had persisted through the many years since their



Fig. 8. The luxury of helicopter transport in the 1970s. Here, a National Park Service Landmark Survey Program has landed atop one in a field of pingos, others of which can be seen in the background.

creation.

In the landmark survey for the National Park Service, we visited a site on the Canning River near Shubelik Springs where a stand of poplars (*Populus* sp.) was known to occur. These were tall, upright trees that seemed out of place on the tundra, and were growing on a gravelly terrace (Fig. 10). I took increment cores to determine the ages of some of the larger trunks but these were lost in shipment. I mentioned these trees to Prof. Eric Hultén, author of the *Flora of Alaska* (1968). He thought that they might have moved onto the North Slope during the Hypsithermal period, just after the last Pleistocene epoch, when the climate was quite a bit warmer than it is now. From pollen records in bog deposits, it is known that tree lines were farther north



Fig. 9. Tundra scars visible from space: tractor trails from exploratory 'cat' trains in the days of Pet-4 exploration. According to the notes archived with this image, "it took six tractors from July 7th (1951) to 12th to accomplish [this move of a cat train across the tundra]. The lead tractor, which could not pull a load, was taxed to its capacity by bulldozing a furrow down to the permafrost zone so the following tractors could secure sufficient footing. As much as 18 inches of thaw was encountered in some places... By comparison, the same load could be transported in winter in 1½ days with 2 tractors..." [USGS Professional Paper 305-G]. Photo of Knifeblade Ridge, 1969, by J. Hok, from the collection of Dave Norton.

in North America at that time. Other stands of poplar occur in the foothills and on the upper, east-flowing course of the Colville River.

North Slope tundra topography viewed from the air appears uniform. Yet from the intimate views that we obtained during overland and river trips and helicopter surveys, patterns of striking topographic and ecological diversity emerged. Plant ecology that distinguishes each drainage basin hints at rich and varied regional histories. I continue to marvel at the diversity that we recorded across Alaska's North Slope during these explorations.



Fig. 10. Trees on the North Slope, Canning River, near Shubelik Springs. Poplar (*Populus*, sp.) stands that are also known from isolated locations elsewhere on the North Slope.

These are a few reminiscences and images of the adventures we had on the North Slope out of the old ARL lab, and later NARL, and they are probably common in the group of scientists contributing to this volume. Frankly, I'd like to start these explorations all over again.

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Coastal Processes And Their Influences On The People Of Alaska's North Slope

H. Jesse Walker¹

ABSTRACT: The lengthy coastline of the North Slope Borough comprises a variety of forms including bluffs, barrier bars, lagoons, and deltas. The open coast and riverbanks are subject to erosional processes not often encountered at lower latitudes. These processes include the action of sea ice and, during the ice-free season, wave action and thermoerosion.

Key Words: North Slope Borough, Arctic Ocean, coast, erosion, permafrost, ice wedge, thermoerosion, *ivuvik*, tides

INTRODUCTION

The North Slope Borough (NSB) encompasses a surface area of 228 000 km² (88 000 square miles) making it larger than 39 of the 50 states in the Union (its size would rank it just above the State of Utah). Bounded by mountains to the south and by two seas of the Arctic Ocean to the north and west, the NSB is a naturally self-contained geographic unit. Until recently, inhabitants maintained relatively infrequent contact with people outside the boundaries of this geographic (and now political) unit. Before air travel became routine in the North, most contact was confined by the relative ease of surface travel to a narrow band along this region's 3000-km (2000-mile) marine coastline, which accounts for just over one-fourth of the general coastline of Alaska (10 686 km—Walker 1985:1). For all but the most recent years in human occupancy of the North Slope, this coastline has served to concentrate both habitation and economic endeavor, and will undoubtedly continue to do so.

Just as archaeological sites across the North Slope are concentrated along the marine coast and on river shores, oceans and riverbanks attract modern communities' site selections. Three of today's eight NSB communities originated through relatively recent establishment, or re-establishment, and choice of sites: Pt Lay on the Chukchi coast by Kasegaluk Lagoon, Nuiqsut on the Colville River Delta; and Atkasuk on the Meade River. All were formally settled in the early 1970s, encouraged by the Alaska Native Claims Settlement Act of 1971. Anaktuvuk Pass is the North Slope Borough's only non-coastal, non-riparian community. The vast majority of today's 6000 North Slope residents thus live in marine-resource-dependent communities located along the coastline (Fig. 1).

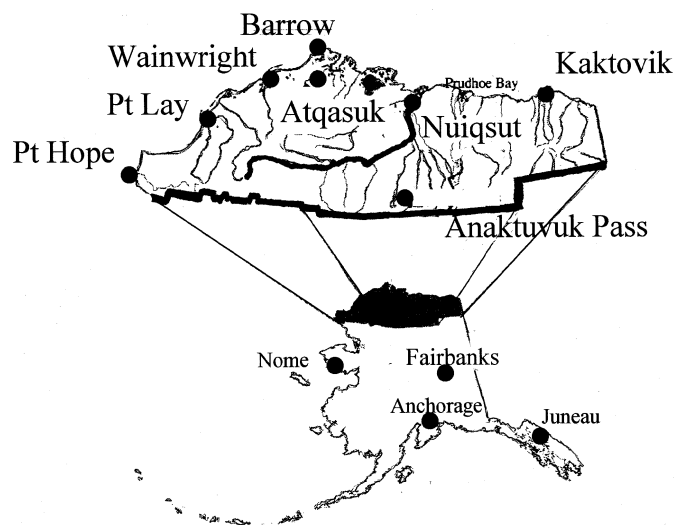


Fig. 1. Exploded view of the North Slope Borough, showing the coastal and riparian location of all but one of its modern communities.

COASTAL CHARACTERISTICS

The northern coastline of the NSB stretches from Demarcation Point (69° 45' N; 141°00' W) on the Canada-Alaska border, west to Point Barrow (71° 30' N; 156° 30' W). This stretch of the coast faces the Beaufort Sea in which the alongshore oceanic current is westerly (that is, it generally flows east-to-west). From Point Barrow the coast angles to the southwest past Cape Lisburne, and from there to just south of Point Hope (68° 20' N; 166° 50' W). Along this western coastline, the coast faces the Chukchi Sea, in which northeasterly (flowing sw-ne) alongshore currents dominate (Walker 1985).

The Beaufort Sea portion of the Borough's coastline is characterized by low cliffs, or banks in the range of 1.5-5 m (5-15 feet), except where these are interrupted by numerous rivers. These rivers and streams flow northward from higher ground to the south, and carry

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water from precipitation falling as far away as the drainage divide along the crest of the Brooks Range. Although most of these low cliffs face shallow lagoons, some face the open sea (Hartwell 1973). The largest interruption of these coastal forms is the delta formed by the Colville River at a location about halfway between Barrow and Kaktovik (Walker, this volume).

The Chukchi-facing coastline differs from that of the Beaufort Sea. Its cliffs are higher than those along the Beaufort Sea, generally 8-16 m (25-50 feet) but reach a height of 300 m (980 feet) at Cape Lisburne. Much of this southwest-trending coastline has lengthy spits and barrier islands that are bisected by narrow inlets and are separated from the mainland shore by extensive elongated lagoons and embayments. By attracting wildlife and facilitating travel in all seasons, these protected waters further increase the human motivation to inhabit the coastal zone where they occur.

COASTAL PROCESSES

The very dynamics that make coastal zones attractive for human habitation challenge inhabitants to adapt and cope with the risks of living in these especially dynamic environments. Although the foregoing statement applies generally to coastal zones anywhere in the world, the NSB coastal zone is quite special: its dominant features and processes have few analogs elsewhere. Another way of saying this is that the vast majority of visitors to the Arctic, including scientists and engineers, bring almost no direct personal experience from temperate or tropical regions of the world that prepares them to grasp the unique coastal dynamics in this region of the Arctic. Only a handful of people can talk about these unique coastal processes from direct personal experience (see text box).

Much of the uniqueness of the coastal processes affecting the coastline of the NSB can be attributed to weather and climate. The entire coastal zone of the NSB lies within the region of continuous permafrost that dominates much of the arctic terrestrial zone. Average annual air temperatures below freezing long ago gave rise to permafrost-related manifestations on and beneath “dry” land. These include ice wedges, ice-wedge polygons and thaw lakes. Besides explaining the great depth (as deep as 700 m, or 2300 feet) of permanently frozen ground beneath the land surface, low air temperature at the earth’s surface is responsible for the freezing of lakes, rivers, and the sea, as well as the maintenance of a persistent snow cover. The temperature regime is also a major factor in determining the seasonality of coastal processes. During most of the year, shorefast sea ice and snowdrifts protect the

“When is Low Tide Here?”

One of the peculiarities of the NSB coastal zone that perplexes some visitors is its lack of noticeable oceanic tides. The daily rise and fall in sea level caused by gravitational pull of the moon and sun is so slight (about 12-18 cm, or 6 inches) that it is dwarfed by almost any weather-related event, such as a change in barometric pressure, or strong winds far offshore. Visiting biologists sometimes either have to be told several times, or shown firsthand, before it sinks in that there is no local “intertidal zone” on the Chukchi or Beaufort Sea coastlines. Beachcombers from southern states sometimes express bewilderment at the absence of “tide pools.” One prestigious engineering firm, while designing a coastal project at Barrow, telephoned four times to request mariners’ tide tables. It did not compute for them to hear, “No, you don’t have to worry about tidal flats; no, your small boat won’t get grounded offshore by falling tides.” Bridging this gap of understanding required me to explain the Arctic Ocean as if it were a very big, salty lake with ice in it, all subject to violent weather—but not subject to celestial tides.

—Dave Norton.

shoreline and coastal bluffs from erosion. River transport of sediment to the sea in the Arctic is shut down for all but a few weeks each year. For most of the year fresh water at the surface stays in its solid phase on lakes, in rivers and in the thin active layer (seasonally thawed surface) of the soil. Weather and seawater-induced coastal modifications along the Beaufort and Chukchi coastlines are likewise compressed mostly—but not entirely (see “*Ivu*” discussion, below)—into short open-water seasons.

For southern visitors, the extreme seasonality of NSB coastal processes takes getting used to. Imagine asking people to make sense of a 12-minute videotape, consisting of 8 minutes of freeze-frame images, wrapped around 4 minutes of fast-forward action. As summer solstice approaches, it is as if 7-9 months of cold, white serenity is shattered by pent-up geophysical energy. First the rivers and freshwater lakes break up, followed weeks later by nearshore sea ice loosening its grip on the shorelines. To illustrate the dramatic concentration of coastal processes, this chapter explores several examples of seasonality, and concludes with attempted countermeasures taken by engineers to control or slow the general rate of coastal retreat.

BLUFF EROSION

The annual season of open water along the coast is brief, wave action regularly erodes the shoreline, and may cause dramatic episodes of bluff retreat (Harper 1978). When waves or currents hit a shoreline with enough energy, they can eat away rapidly at the frozen sands or gravels at the base of coastal bluffs, undercutting them, and forming what are called “thermoerosional niches” (Walker and Arnborg 1966).

Thermoerosional niche formation actually combines two physical processes going on at the same time. First, the ground ice that cements the soil particles together is melted by heat transferred to that ice from the liquid water—the “thermo-” part of thermoerosion. Second, freed from years to thousands of years of being glued together by freshwater ice, the particles are now being tossed around and carried away by the currents or waves—the “-erosion” part of thermoerosion. These niches take the form of horizontal wedge-shaped gaps (Fig. 2) that cut far enough beneath overhanging bluffs to de-stabilize whole sections of bluff, and to cause their eventual collapse. Bluffs that are undercut by these niches often fall as house-sized blocks, by tipping or tumbling into the sea or river that is responsible for thermal erosion (Fig. 3). When a section of bluff collapses, it is likely to break away from the surrounding soil in bluffs along planes of weakness formed by clear-ice wedges (Fig. 4). These are the vertical ice wedges that underlie and define the polygonal ground typical of tundra along much of the coastline. Many ice cellars and archaeological sites along the bluffs at Barrow have been exposed and destroyed by these processes of block collapse (Walker 1991a).



Fig. 2. Lennart Arnborg, in 1962, standing in rubble beneath an overhanging ice wedge in a thermoerosional niche, Colville River.



Fig. 3. Block collapse along bluffs of Chukchi Sea shoreline, illustrated at Barrow, in the wake of a fall storm. Photo, courtesy of Bill Hess, Copyright Running Dog Publications.



Fig. 4. Johan Peippo and an ice wedge on the east bank of the Colville River in 1962. This picture appeared on the cover of *ARCTIC* in 1963.

Blocks also collapse commonly along riverbanks. For example, many of the bluffs of the Colville River delta undergo such collapse (Fig. 5). The bluffs in the Gubik Formation to the north of Nuiqsut are retreating at an average rate of 1 m (3 feet) per year; those at Nigilik have retreated more than 50 m (150 feet) since 1949. In 1986, George and Nannie Woods' house, originally built in the late 1940s on a site 50 m from the riverbank had to be moved back. By moving it 30 m (100 feet) farther from the bank, the Woods family can hope to have earned a 30-year reprieve for their building.

Block collapse, summarized diagrammatically in Figure 6, is the most dramatic, but not the only manifestation of bank erosion. Normal seasonal thawing of the active layer and of permafrost exposed to sunlight and warm air on the cliff face result in sloughing and slow retreat. By contrast with block collapse, this sloughing is a relatively slow release of granular soils



Fig. 5. One of the nearly degraded collapsed blocks in 1962, at the site where the community of Nuiqsut is now located.

from the ground ice that held them in place. Grains of clay, silt, sand and gravel typically dribble or rain down the cliff face; occasionally the steady stream is punctuated by slumps, or massive landslides. Natural rates of bluff retreat by sloughing are accelerated by human activity along bluff edges, and on bluff faces.

Wind is also a major contributor to coastal modification, especially during those periods of time when sea ice is farthest from shore. Wind-generated storm waves at times may be especially damaging (Fig. 7). Such was the case in September 1986 along the Chukchi Sea coast. Several days of continuous westerly winds blowing over a large open sea caused extensive bluff retreat at Barrow and Wainwright (Walker 1991b). Houses had to be moved back from the bluff edge at both locations (Fig. 8). Severe storms also occurred in 1954 and 1963. Both storms extensively reworked and reshaped the coastal beaches. The 1963 storm piled sea water into the NARL camp to depths of 1 m (3 feet) and extensively damaged equipment, buildings and research endeavors. In Barrow, 32 homes were

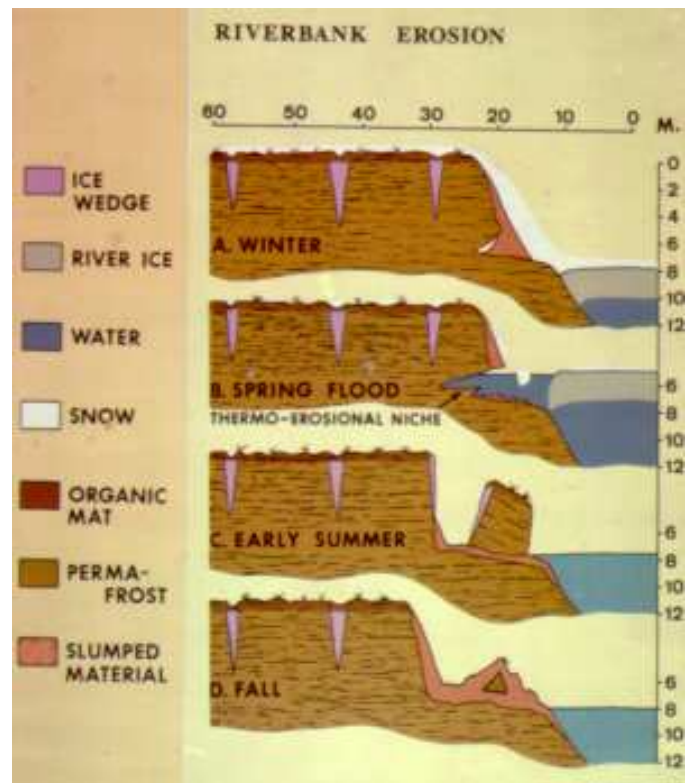


Fig. 6. Riverbank and ocean bluff erosional processes Summarized by seasonal progression of events.



Fig. 7. Fall storm surf, coinciding with maximum sea ice retreat, and greatest fetch for westerly-wind-driven waves from the Chukchi Sea at Barrow and Wainwright. Photo, courtesy of Bill Hess, Copyright Running Dog Publications.

dislocated from their foundations, and 152 people were evacuated. Whale boat and other small boat damage was estimated at \$50 000 as a result of that storm (ARL 1963; Hume and Schalk 1967).

Coastal impact is not entirely restricted to periods of open sea because arctic storms can cause damage even during periods when sea ice is up against the shore. The movement or surge of ice over the shore and up the



Fig. 8. House at Barrow, partially overhanging eroded bluff as a result of fall storm-induced erosion. Photo, courtesy of Bill Hess, Copyright Running Dog Publications.

bluff face, often on top of a snow ramp, is known in Iñupiaq as *Ivu*. A recent *Ivu* occurred in February 1989. That storm left large ice rubble pile-ups on the beach at Barrow (Fig. 9). These piles, incidentally, helped protect the beach from erosion during part of the following summer.

BEACH MODIFICATION

Although the most spectacular modification along the shoreline occurs with bluff retreat and block collapse, the beach itself is also modified as described above in connection with the 1989 *Ivu*. As the summer beach, which may still have scars left from the previous winter and spring, begins to freeze, a mixture of the mineral and organic matter on the beach, frozen sea water, and snow accumulates and during the winter season becomes a frozen heterogeneous and irregular mass. Events during freezeup thus leave more or less random “signatures” along the shoreline, which in turn persist



Fig. 9. Ice override (“*Ivu*”) in Barrow, February 1989, showing broken utility pole. Photo, courtesy of Bill Hess, Copyright Running Dog Publications.

to affect the dynamic balance of beach modifications in the next season or seasons. Through wave action, for example, larger blocks of sea ice are added on top of the mass or “bulldozed” into it especially during fall storms before freezeup. The thickest pieces of multiyear ice may persist at the beach edge until the following mid-summer, forming temporary barriers between the beach and the energy of the sea.

COASTAL ENGINEERING

Because most NSB residents live on the coast, natural changes in the shoreline can be disastrous. Therefore, it is not surprising that a number of efforts have been made to mitigate such changes. Tar drums have been used as seawalls at Browerville and Wainwright. At Wainwright drums were placed along the bluff face prior to the 1986 storm and probably aggravated wave impact. They were in disarray after the storm (Fig. 10) and removed. Because of the 1986 storm and subsequent wave attack, seawalls have been constructed along the bluff at Barrow.



Fig. 10. Destruction and scattering of bluff-armoring tanks along the Chukchi Sea coastline. Photo, courtesy of Bill Hess, Copyright Running Dog Publications.

The most recent attempt (1996-present) at reducing potential damage is the initiation of a renourishment (“Beach Nourishment”) capital improvement project at Wainwright and Barrow. By extending to the ocean the technique of hydraulic dredging, previously used in rivers and lagoons, sand is pumped from offshore to beaches, with the intent of both widening and thickening them (Walker 1994). In severe storms this is the first material to erode away. The artificially thickened and widened beach is “sacrificed,” but the process takes time, and reduces the time that storm waves can vent their energy directly on the base of the coastal bluffs.

CONCLUDING REMARKS: GLOBAL CLIMATE CHANGE

This chapter highlights some of the peculiar dynamics of the North Slope coastal zone, and how challenging it is to portray both scientific and personal experience gained through the first 50 years of NARL's existence. Now, as world attention focuses increasingly on the specter of climate change, the processes described here should be appreciated for their especial vulnerability to Global Change, or to so-called "greenhouse warming" (Walker 1992: 568). A degree or two of worldwide warming, if distributed perfectly evenly round the globe, would bring about disproportionately large changes in coastal equilibria for the Arctic, because of the greater relative effect of any small divergence in temperatures near freezing. The outlook, however, is more disturbing if General Circulation Models (GCM) and direct observations continue to show that the western Arctic is likely to sustain some of the planet's greatest absolute temperature increases. Implications of a pattern of warming into the new millennium for the processes illustrated here, and implications for the predominantly coastal-resident people of northern Alaska argue for both concern and scientific attention.

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Studies of Fresh Waters on the North Slope

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ABSTRACT: Investigators at the ARL and NARL and their successors have asked a variety of questions about fresh waters ranging from the distribution of fish and microscopic animals to the orientation of lakes and the survival of animals in frozen ponds.

Modern studies emphasize that lakes, ponds, streams, and rivers can only be understood as a part of a larger system that includes the drainage basin. Three illustrative studies of fresh water are presented. The first is about phosphorus, a vital element for plant growth, and how its availability in pond water controls the microscopic algae. This availability depends upon the amount of iron in the sediments. The second is about large lake trout in deep lakes away from the coastal plain. When the lake trout are overfished, then smaller fish are able to multiply and the whole food chain of fish and small floating animals is changed. The third illustration concerns the changes in freshwaters that are beginning to take place from climate warming. As the upper waters of lakes become warmer each summer, the fish must move deeper and deeper to find the cool water they need to survive. Eventually, they may become extinct in parts of the Arctic.

Key Words: fresh waters, lakes, ponds, North Slope, phosphorus, iron, lake trout, carbon dioxide, global change

INTRODUCTION

The study of arctic freshwaters includes ponds, lakes, streams, rivers, and springs. Various aspects of freshwater studies have been carried out at Barrow and on the North Slope for over a century, beginning with collections of small planktonic animals made in the 1880s. These early studies were carried out by various expeditions such as Steffansson's Canadian Arctic Expedition (Johansen, 1922, Stefansson, 1921).

In the 1950s, investigators at the ARL and NARL first asked what animals and plants are found in nearby lakes and ponds and how do they survive the winter. One famous investigator, Per ("Pete") Scholander, described how the insect larvae that stayed in the ponds for up to four years before emerging as adult midges could survive freezing as long as the temperature stayed above -18°C (0°F) (Scholander et al., 1953). Another series of studies began with the question: why are so many of the large lakes of the coastal plain oriented in the same direction? The answer was that the prevailing winds, mostly from the east or west during the summer, created currents of water that carried heat to the ends of the lake where it melted the permafrost (see Carson, this volume). Several scientists, among them Dan Livingstone and John Hobbie, studied

some of the large lakes in the Brooks Range to ask how the Arctic environment changed the ecology of fresh waters. Hobbie's (1964) study of Lake Schrader, now in the Arctic National Wildlife Reserve, revealed that more than half of the primary productivity, that is, the yearly growth of the small algal plants, took place beneath the ice cover in a year with an exceptionally long-lasting ice cover (Fig. 1).

To illustrate some of the results of freshwater studies of the past 50 years, three topics will be described: how nutrient inputs control the ecology of lakes and ponds, how lake trout control the other animals of large lakes, and how climate change will affect the ecology of freshwaters.

ILLUSTRATION 1: NUTRIENTS

The smallest plant life in ponds and streams are the algae — they are so small that a microscope is needed to see them. For growth, the algae require many different kinds of minerals but the nutrients nitrogen (N) and phosphorus (P) are present in such low amounts that they limit growth. In ponds and tundra near Barrow, most of the phosphorus is bound in organic forms in peats and soils. When bacteria decompose the organic material in the soils and pond sediments, a small amount of the phosphorus moves into the water but most is trapped by iron (Prentki et al., 1980) and remains out of the reach of algae. This iron trap is active in both ponds and lakes; it is responsible for holding phosphorus at very low levels, so low that there is only a low rate of algal growth.

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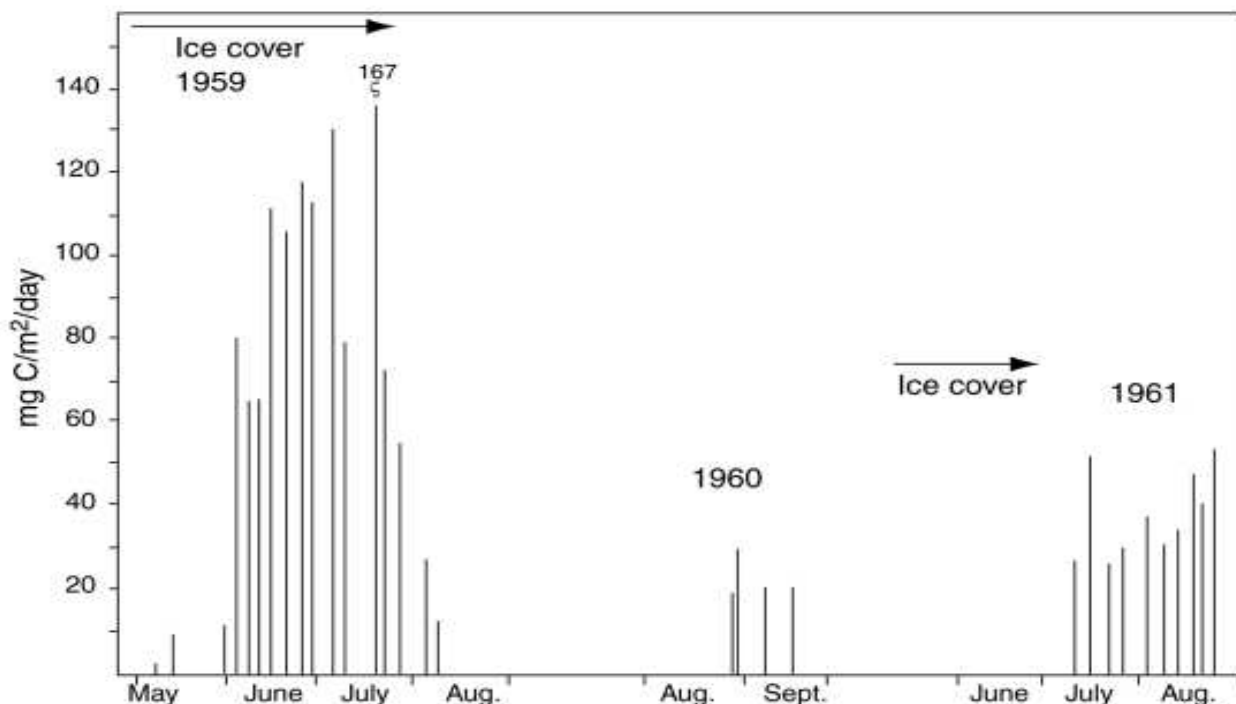


Fig. 1. Primary productivity (^{14}C) in Lake Schrader, Brooks Range, Alaska. Modified from Hobbie (1964).

What happens when humans add nutrients to freshwaters in the Arctic? This can happen when sewage lagoons discharge into streams and when soil is disturbed by construction or melting of permafrost. In ponds near Barrow, the sediments contain a great deal of iron so that when phosphorus is added at low rates there is enough iron to bind up the phosphorus. In other words, low levels of disturbance can take place without causing large amounts of algal growth. In contrast, a high level of disturbance will cause a rapid growth of the algae. In a shallow pond near Barrow, the addition of 46.5 g P had little effect; the addition of 232 g P three days later strongly increased the rate of productivity (Fig. 2; Alexander et al., 1980).

The same response of the algae was found when phosphorus was added to an entire lake in the foothills near Toolik Lake (Hobbie et al., in press); this lake was fertilized by added phosphorus and nitrogen every week in the summer for five years. The added phosphorus became bound to the iron oxide layer for the first five years of fertilization and could not be recycled to overlying waters. By the last year of fertilization, the sedimentation of algae to the sediments had depleted the iron oxide layer because of iron sulfide formation, allowing large fluxes of phosphorus from the sediments. This flux produced a high level of algal growth as so much phosphorus had been added that there was no more iron available for the binding reaction. After the fertilization, we wondered how fast would the lake recover? In temperate regions this

recovery may take many years. In this arctic lake the recovery has been remarkably fast. In just one year the phosphorus was again completely trapped by iron in the bottom sediments of the lake.

ILLUSTRATION 2: LAKE TROUT

The food chain of arctic lakes begins with the algae; these are eaten by small animals (zooplankton) and these in turn are food for small fish such as grayling (*Thymallus arcticus*) and whitefish (*Coregonus*, spp). At the top of the food chain are the predatory fish that usually eat only other fish, such as the lake trout (*Salvelinus namaycush*) and the burbot (*Lota lota*). In Toolik Lake, located in the northern foothills of the Brooks Range; however, researchers reported (O'Brien et al., 1997) that most of the food that the grayling and lake trout consume does not come from the food web of the water (pelagic food chain in Fig. 3) but, instead, comes from the animals, such as snails, that live on the bottom of the lake (benthic food chain in Fig. 3).

The large lake trout, up to 1 metre (39 inches) in length, are also sought after by fishermen. Because it can take 15 to 20 years for lake trout to reach large size and there are fewer than 100 large lake trout in most lakes, the large lake trout can be completely removed by only a few years of moderate fishing pressure. In the continental U.S. there are no lakes left with untouched stocks of lake trout but the interactions of completely natural populations may still be studied on the North

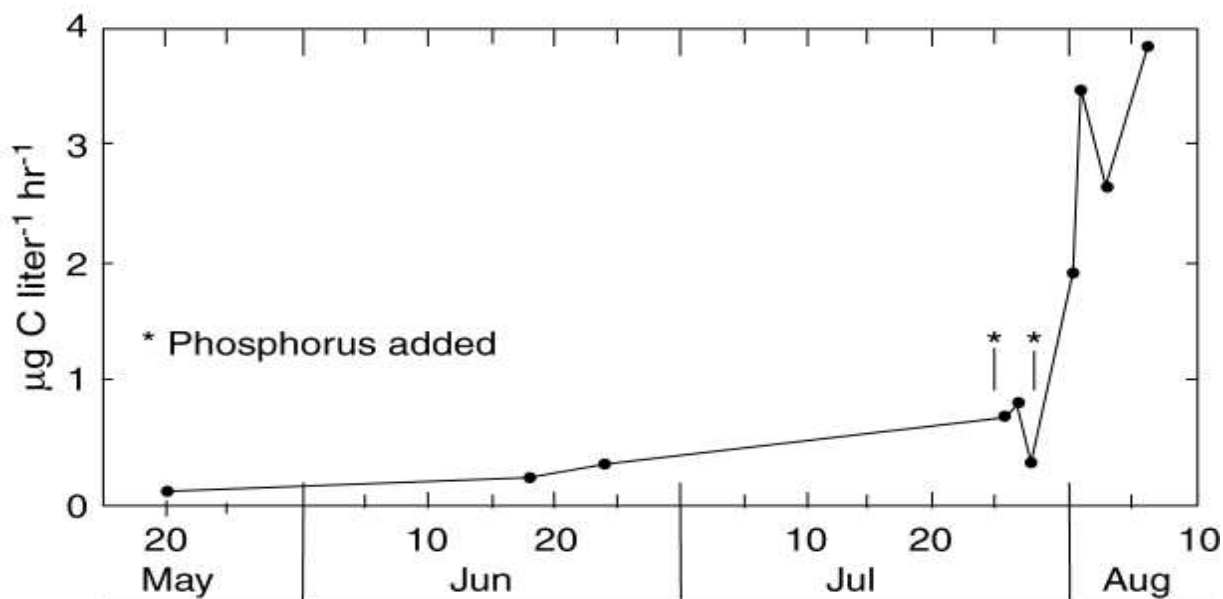


Fig. 2. Primary productivity of phytoplankton (^{14}C) in Pond D (Barrow, Alaska) before and after the addition of 46.5 g P on 25 July and 232 g P on 28 July 1970. Modified from Alexander et al., 1980).

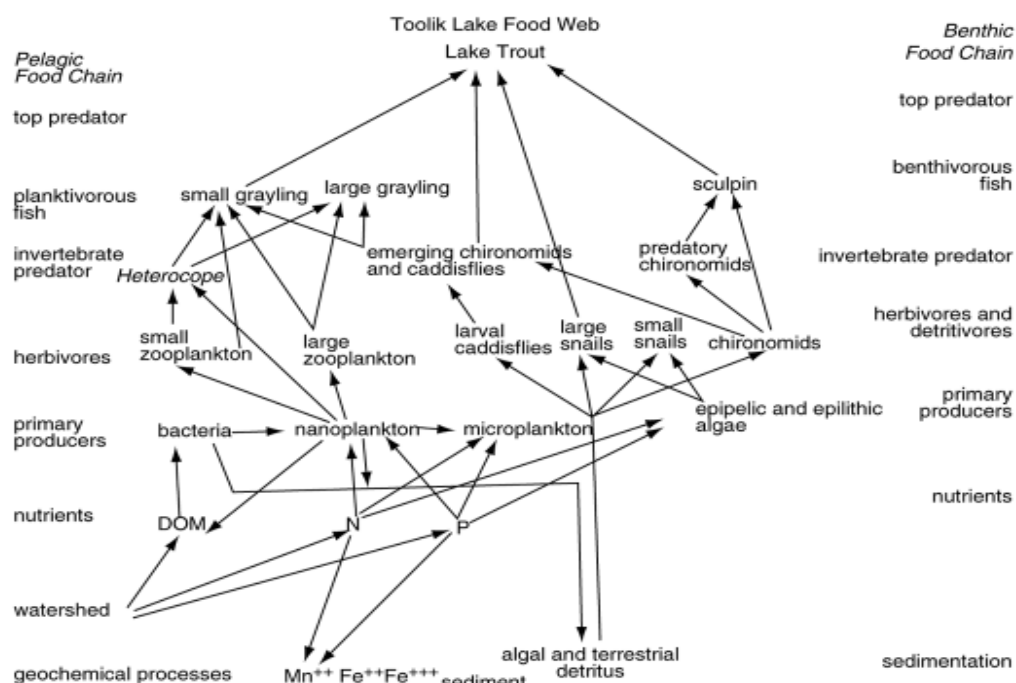


Fig. 3. The food web of Toolik Lake, North Slope, Alaska (modified from O'Brien et al., 1997).

Slope. Incidentally, most of the lake trout in a lake are old and small; only a very few make the transition to eating other fish and are able to become old and large.

What happens to the animals and plants of an arctic lake when the top of the food chain, the large lake trout,

is removed? At Toolik Lake in the foothills of the Brooks Range the pipeline construction camp was active from 1970 to 1976. When researchers began to study the lake food chain in 1975 they found no large lake trout and did find relatively large zooplankton, up to 2 mm in length. In subsequent years these

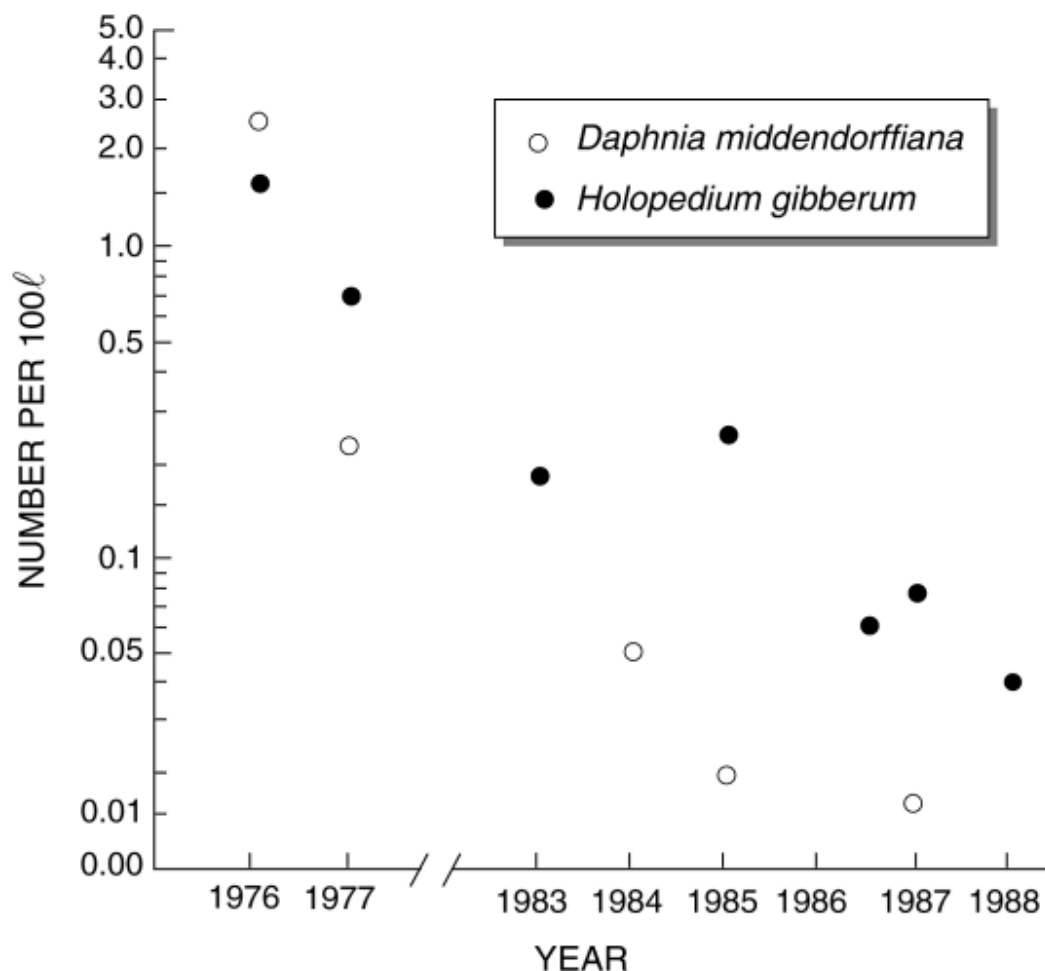


Fig. 4. The abundance of large-bodied zooplankton in Toolik Lake, 1976–1988 (modified from Hobbie et al., 1995).

zooplankton became rarer and rarer (Fig. 4). The best explanation (Hobbie et al., 1995) was that with the removal of the largest fish, the smaller fish survived better and became bolder. Grayling and young lake trout were able to feed on zooplankton throughout the lake instead of hiding from larger fish along the rocky shoreline. Thus, when the numbers of fish at the top are low, the numbers of fish one step down in the food chain will increase and the numbers of zooplankton—two steps down—will decrease.

To test this explanation, the researchers chose a nearby lake with large trout, studied it for some years, and then removed the adult lake trout to see if their prediction was correct. The expected result did happen: the numbers of small fish rose dramatically. When this happened, the zooplankton were drastically reduced in numbers. Another result was the dramatic increase in the growth of some of the lake trout (Fig. 5). For example, 10–12 year old trout weighed 250–1000 grams at the start of the removal period, in the late 1980s. Ten years later, the 10–12 year old trout weighed 1300 to 2300 grams. One possible reason for the increased growth is a behavioral release (the small

fish can forage in the open because there were no large predaceous adults around). Another possible explanation is that there are fewer fish and so each fish has more food available. There could also be a combination of these two possible explanations.

ILLUSTRATION 3: CLIMATE CHANGE

The climate of northern Alaska has been warming in recent years. While it is too early to say whether this trend is the first local sign of a planet-wide warming caused by an increase in carbon dioxide in the atmosphere, it is not too early to learn about some possible changes that may occur in arctic freshwaters in the future and about some things that are happening in lakes and streams that may affect that future.

One question is: are arctic lakes giving off carbon dioxide or taking it up? The first reaction was to guess that the lakes were taking up carbon dioxide from the atmosphere because small amounts of phosphorus were continually entering the lakes and allowing algae to take up carbon dioxide and grow. The surprising

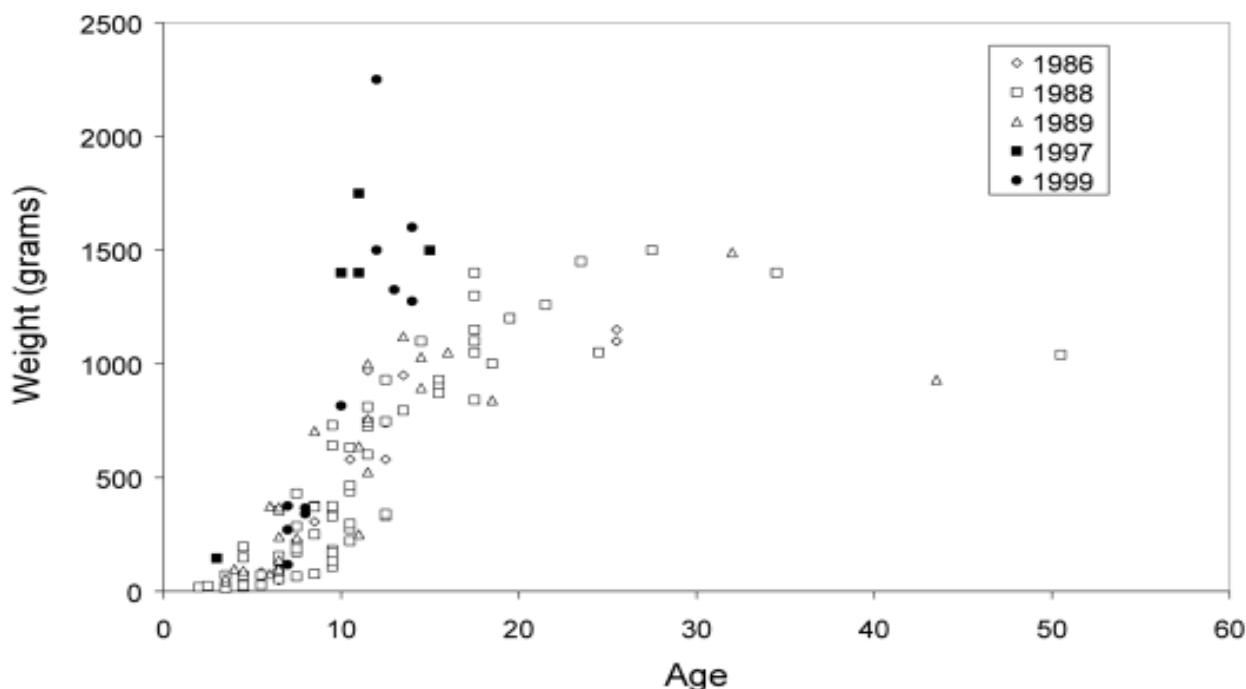


Fig. 5. The age and weight of lake trout collected from Lake NE12, near Toolik Lake, Alaska. All adult lake trout were removed in 1986, 1988, and 1989. The fish were aged by examination of their ear bones (otoliths).

results of the field measurements were that arctic lakes are giving off relatively large amounts of carbon dioxide. How can this be explained? The answer was that the waters that enter these lakes in seeps or in streams contain large amounts of carbon dioxide (Fig. 6). These waters, in turn, have gained the carbon dioxide in their passage through the soil where intense microbial breakdown of leaves and roots provided ample carbon dioxide. Most of this soil carbon dioxide moves directly up to the atmosphere, but at least 20% of the carbon dioxide leaves the soil dissolved in the water. Eventually the dissolved gas reaches a stream or lake where the carbon dioxide is released to the atmosphere (Kling et al., 1991).

Another question is: how will climate change affect the fish in arctic lakes? Each species of fish will probably be affected in a different way but there is good evidence that the lake trout populations will be harmed. These fish require cool temperatures and an abundant supply of oxygen. At the present time in the foothill lakes of the North Slope the upper waters become too warm for lake trout during the summer. They are therefore restricted to the deeper and cooler waters, below 5-7 metres (15-21 feet). With warming, the cooler waters are expected to lie even deeper so the lake trout will be squeezed into a smaller space. It was also found in the lakes studied near Toolik that the oxygen was reduced in the deep waters, a result of more growth of algae and, later, more decomposition

of dead algae in the deep waters. This reduction in oxygen may occur in the future if more phosphorus reaches these lakes. Through these two changes—a warmer temperature and lowered oxygen in the deep waters—the living room of the lake trout would become restricted to a 3-metre (10-foot) layer of water where they could find both enough oxygen and cool enough temperatures (see Hobbie et al., (in press) for a detailed explanation).

In all these examples, it is obvious that the freshwaters of the North Slope are strongly affected by changes on the adjacent land and that their ecology is already undergoing modification by humans. There is also the strong potential that climate change will have an equally large effect in the future.

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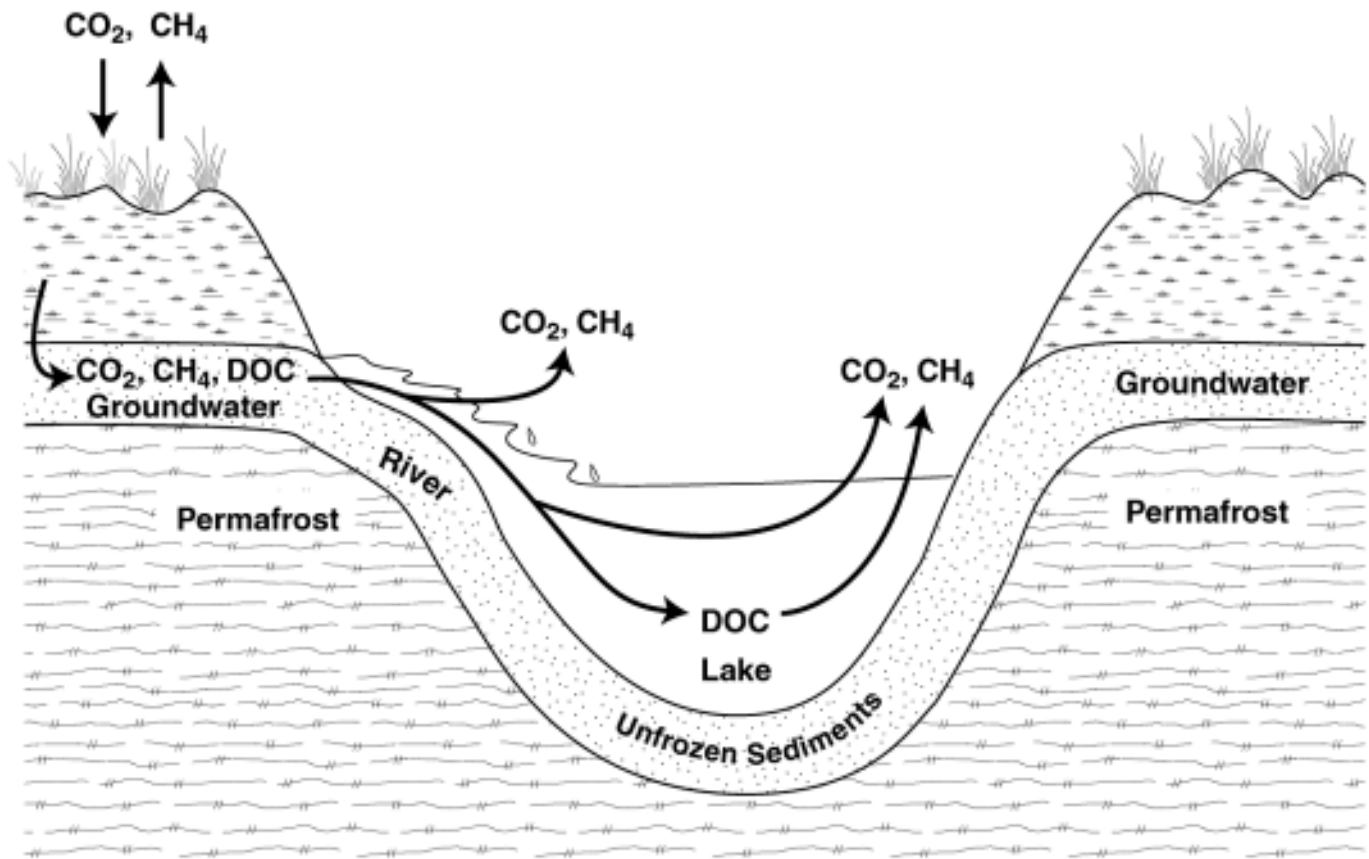


Fig. 6. A conceptual diagram of the tundra carbon cycle. Carbon dioxide (CO_2) is taken up by plants in photosynthesis. Respiration, methane (CH_4) formation, and decomposition in the soil lead to transfer of CO_2 , CH_4 , and DOC to streams and lakes. Eventually the lake CO_2 and CH_4 are released to the atmosphere (redrawn from Kling, 1995)

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The Oriented Thaw Lakes: A Retrospective

Chas. E. Carson¹

ABSTRACT: The author retraces his initiatives 40 years earlier, to discriminate between explanations for the NNW-SSE orientation of the long axes displayed by shallow thaw lakes covering much of Alaska's Arctic Coastal Plain. These lake-orientations are especially clearly illustrated near Barrow, but are shown to extend widely.

Key Words: Differential erosion, lake cycles, endogenic mechanisms, exogenic events, lake current velocities, lake bottom profile

INTRODUCTION

As part of a graduate program, I began work in the spring of 1958 in northern Alaska under Dr. Keith M. Hussey of Iowa State University in Ames. Supported by the ONR and the Arctic Institute of North America (AINA) his research concentrated on the geologic history and geomorphology of the Arctic Coastal Plain. There were projects on patterned ground, permafrost, the lake cycle, sedimentation, and the Gubik Formation. My research concerned thaw lake orientation and, later, carbon-14 dating of the thaw lake cycle. This investigation modified and confirmed aspects of previous studies.

PREVIOUS STUDIES

Numerous lakes and ponds had long been observed on the Arctic Coastal Plain but it was not until shortly after WWII that the origin of their strong tendency to a uniform shape and orientation attracted much scientific attention. The lakes are all formed in the surface of the unconsolidated sediments of the Late Cenozoic Gubik Formation. Throughout most of this tundra region they are shallow thaw basins in the permafrost elongated in a cigar or tear drop shape, tapering NNW. Near Point Barrow their long axes are oriented NNW-SSE, with an average of about 10-12 degrees west of true north. Many lakes are surrounded by successive older revegetated strands. It appears that there may have been regional episodes of draining (Fig. 1).

Through the decades there have been many discoveries and experiments related to the general problem of lake basin orientation. There were wave tank experiments, geomorphic and sedimentary studies, and much mathematical description and theory. This work included that of Langmuir (1938), Putnam et al. (1947), Keulegan (1951), Saville (1952), and Bruun (1953).

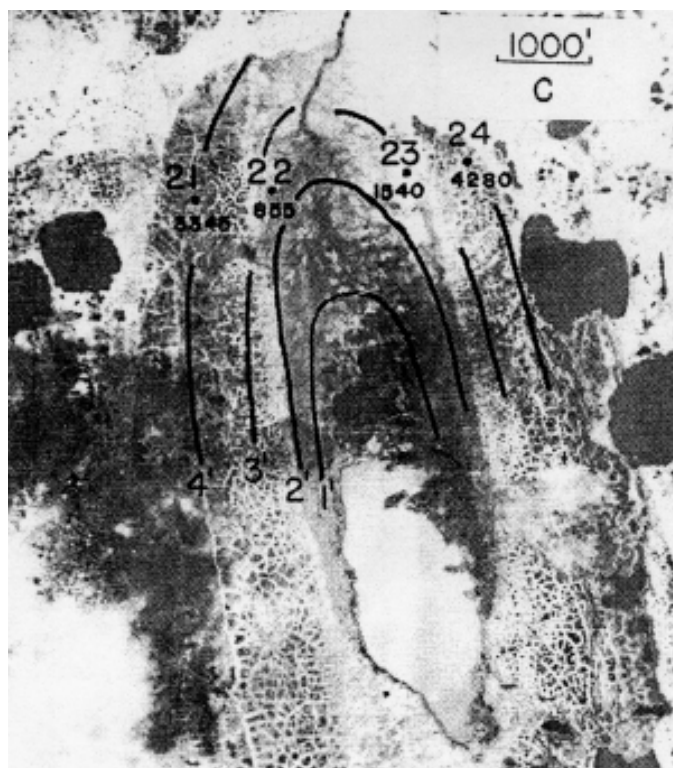


Fig. 1. Revegetated ancient strands surround a remnant lake.

When my investigation began in 1958 there had already been several earlier studies of the oriented lakes near Barrow. Black and Barksdale (1949) suggested that wind-driven erosion had a great influence, proposing an erosive effect of ancient NNW and SSE winds on those ends. Later, however, Livingstone (1954) postulated that the prevailing E and W—perpendicular to the long axes—winds of recent times were the causative agent for perpendicular elongation. His theoretical model suggested that an initially circular basin would eventually become ovoid. Maximum set-up of water on the downwind shore would produce a windward return current that would erode the northern and southern ends, elongating them, and the lakes would thus become oriented (Fig. 2). Still later, Rex (1958; 1960) presented a more detailed mathematical model suggesting that the lake

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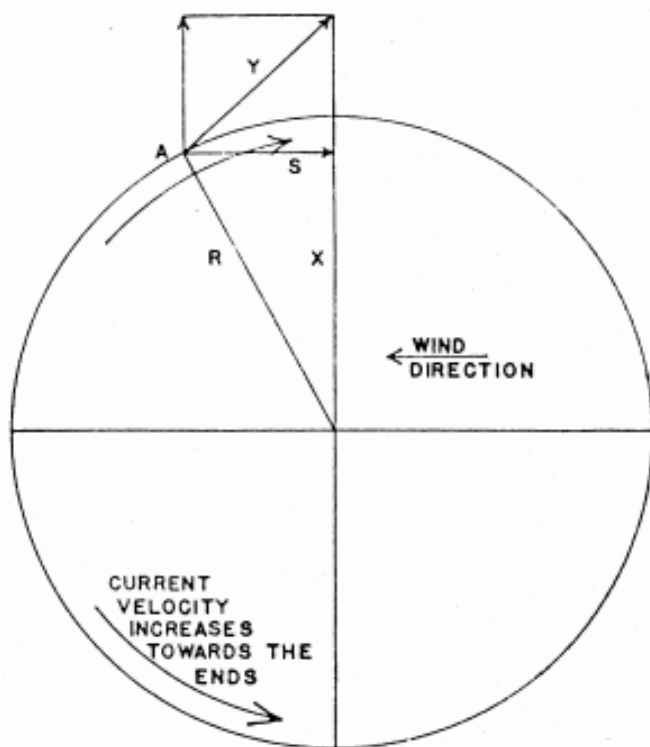


Fig. 2. Diagram modified from Livingstone (1954) showing increased windward current velocity in the ends of a lake.

basins were equilibrium forms, also resulting from the modern wind regime, but with maximum current velocity flowing downwind in the downwind corners (Fig. 3). By then, still other origins had been postulated such as an oriented fracture pattern in the permafrost. (Rosenfeld and Hussey, 1958).

These earlier studies, and their conflicting hypotheses, lacked sufficient field data fully to describe or confirm the actual causal mechanisms, so the purpose of my research was to conduct enough field and laboratory work to confirm, reject, or modify previous explanations. My work benefited not only from previous research, but also from the luxury of more time and greater support from the rapidly-growing NARL. The ensuing investigation tied together pieces of the bigger picture: the underlying permafrost, basin morphology and orientation, sedimentary profiles, wave and current patterns, insolation (i.e., energy from incident solar radiation), water temperatures, seasonal changes, and prevailing winds.

EARLY FIELD WORK—Basin Morphology

Field studies began before breakup in the spring of 1958 with a number of 0.9-m (36-inch)-diameter bore holes augered some 4.5-6 m (15-20 feet) into the

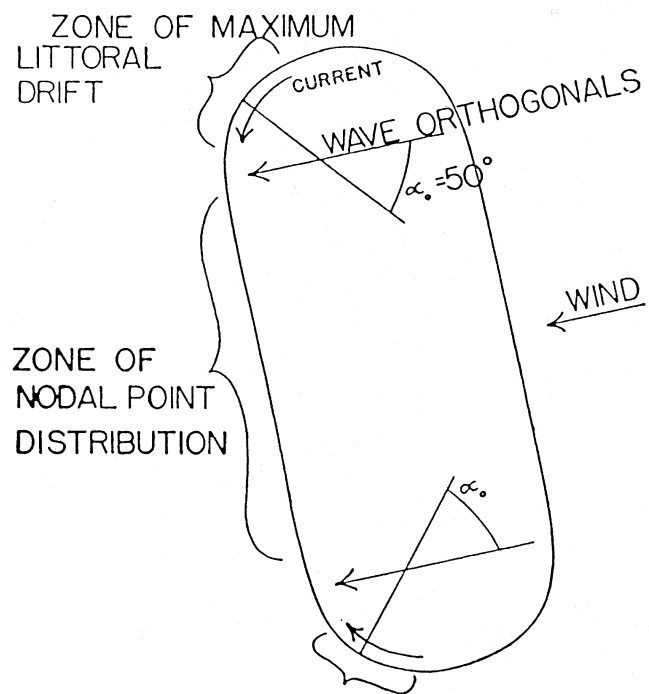


Fig. 3. - Diagram illustrating the relationship between wave orthogonals and zones of maximum littoral drift in leeward corners according to the prediction of Rex (1958; 1960).

frozen ground (Fig. 4). Both lake sediments and the topmost layers of the ice-bound mineral soils of the Gubik Formation were sampled in these test holes. Sampling and mapping of lake bottoms, drained basins, and surrounding tundra continued into the summer of 1958 and for several seasons thereafter. The sampling and mapping near Barrow included Ikroavik, Imaiksaun, Loon, Twin Lakes, and the dry beds of Owl, Footprint and Antler Lakes (Fig. 5). The data were analyzed in the laboratories of both NARL and Iowa State.

The early descriptive phases of research revealed that lakes near Barrow are uniformly shallow, usually



Fig. 4. Auger hole through lake ice into bottom sediments.

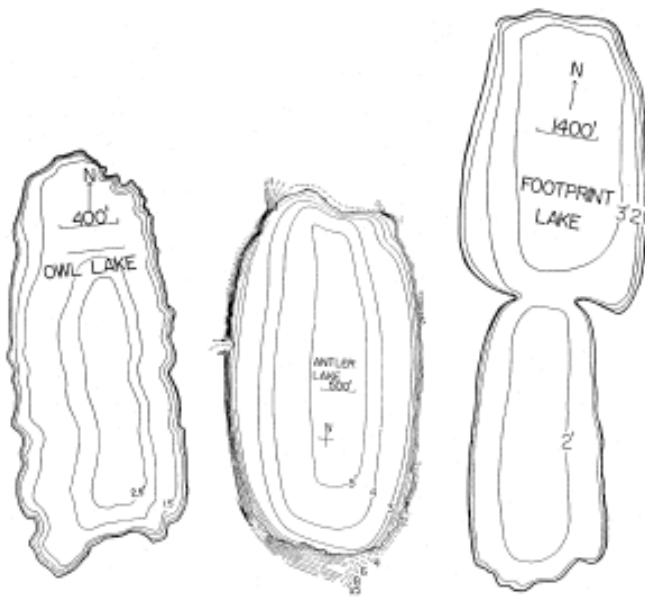


Fig. 5. Topographic maps of several dry lake beds near Pt. Barrow.

less than 2 m (6 feet) deep, with the largest, Ikroavik Lake, being 2.4 - 3 m (8-10 feet) deep. Their basins are wide and flat, gradually shallowing toward the east and west sides over broad wave-cut sublittoral profiles, or shelves. The eastern and western sides consist of beaches of sand, wave-drifted peat, or both. This pattern suggests that deposition prevails at or parallel to these eastern and western shorelines. The western shelves are somewhat wider than those on the east, reflecting the greater dominance of ENE summer winds; both shelves converge more toward the NNW than to the SSE causing the basins to taper NNW, that is, to be narrower toward their northern ends. Axial ratios (long axis: short axis) range from 2:1 to 4:1.

The nearshore profiles or cross-sections at the northern and southern ends, by contrast, show a more abrupt dropoff, and lack sedimentary or depositional shelves of peat or mineral soils. This pattern suggests that erosion is prevalent at these ends.

Thaw lakes are continually going through life cycles much like those of living organisms: from birth through infancy and growth to maturity, followed by senescence, death and decay. Almost every new lake's life cycle begins on top of the remnants, or relict profiles, of one or more previous generations of thaw lakes. An instantaneous overview of the Coastal Plain near Barrow is like a single frame cut from a motion picture film. That frame captures lakes and ponds in one or another of each of the life cycle stages, from formation through decay. The fames range from new puddles and relict ponds to large lakes, and from the bare sediment of a

recently drained basin to old basin sequences completely re-vegetated by tundra plants. Some basin histories have been complex and specific details of individual basin origins and histories vary. The purpose of my project was to look past these complexities and variations to find a tendency toward a common pattern of morphology and uniform orientation throughout the entire lake basin evolution or life cycle. The orientation increases with basin size from the pond stage to large lakes, and the thaw basins continue to expand until drained by either headward eroding streams, the piracy by adjacent lakes or, on the coast, intersection by the sea.

Many small initial ponds with diameters less than 15-30 m (50-100 feet) and half-metre (2-foot) depths appear in outline to exhibit no particular orientation. Others, which form in drained central basins or between successive old beaches (strands) along the sides of drained basins, have oriented shapes from inception (Fig. 1). In both types, however, (Fig. 6) wave-drifted peat bars form sublittoral profiles along the east and west sides and these bars adopt the same orientation as the wave-cut shelves of larger oriented basins. Moreover, just as in the larger basins, these bars are absent from both the north and south ends. As they enlarge, shorelines of initially unoriented ponds gradually assume an oriented taper; those initially oriented become further elongated and tapered. Through detection of a common alignment in the underwater profiles cut through the confusing welter of detail expressed by the surface shapes of the ponds.

The descriptive phase of research set the stage to evaluate region-wide causes and mechanisms to explain the convergence of a generally uniform lake basin pattern manifested by ephemeral, oriented thaw lakes. The contrast between erosional ends (NNW and SSE) and depositional sides (W and E) of the oriented lakes clearly implicated water movements as proximate causes



Fig. 6. Wave-drifted peat bar along the east side of a small thaw pond near Pt. Barrow.

of progressive lake orientation. Among the other causes, insolation was rejected for failing to explain the wider southern ends of oriented lakes; underlying geological structures were rejected for failure to explain differential sedimentation and erosion within basins. Evidence was compelling that every body of water, regardless of size or initial shape, was controlled by some regionally consistent regime. As other explanations failed, the coupling of water circulation to the regional wind regime remained the most plausible ultimate determinant of orientation, as Black and Barksdale (1949), Livingstone (1954) and Rex (1958; 1960) had all postulated.

FIELD WORK — Orienting Processes

To establish more detail about the orienting processes, it was essential to make many measurements of wind-driven lake currents, waves and current action in lakes and ponds of all sizes. Several techniques were used, including standard current meters, several types of floats, and dye markers. These were deployed from shore, from boats, and from the air (Figs. 7 and 8).



Fig. 7. Small float along the moat of Ikroavik Lake during the ice cake stage.



Fig. 8. Dye in the north end of Ikroavik Lake showing the longshore current flowing parallel to the shore. Center of picture.

Temperature distribution was also measured, and combined with the patterns of circulation velocities.

Studies began before breakup to document the effects of ice shove and any early thermal or current differentials around the shores. The effects of ice shove against the shores are variable and sporadic, but for a week or two before final melting, larger lakes consistently develop a shallow moat of open water around a central ice cake (Fig. 9). Although Brewer (1958) showed that lakes and ponds become isothermal when free of ice, thermographs revealed that during the ice cake stage water temperatures tend to average about 2°C (3.6°F) higher in the ends of moats than along the sides (Carson and Hussey, 1960). Faster circulation removes ice frozen to the bottom at these ends, whereas ice



Fig. 9. Open moat around Imaiksaun Lake during the ice cake stage. Woavik is in the background.



Fig. 10. Ice frozen to the bottom of the west shore moat of Ikroavik during the ice cake stage.

remains on the bottom along the sides (Fig. 10). Thus, at this stage depth to permafrost is greater in the ends so that erosion there starts relatively early each season.

Current velocity in the ends around the ice cakes is greater due to a naturally longer fetch than is available

along the sides. Velocities in the moats are essentially zero at the middle of each side but in the windward moat they diverge and increase toward each end where they then join the maximum alongshore flow in a downwind direction. The currents then enter the downwind moat from each end and gradually slow, converging toward the middle where they again cease. Water levels are thus slightly higher on the downwind side indicating that water from set-up there is returned in a broad diffuse pattern underneath the central ice cake. Current velocity around the ends of the ice cakes increases with increasing lake size and in Ikroavik ranged up to 60 cm/sec in the north and south ends under a wind of 1340 cm/sec (about 30 miles per hour—Fig. 11). Events during the ice-cake and moat phase of breakup, however temporary, demonstrate a consistently greater erosive energy persisting in the ends of lakes just as during the longer open-water season. (Carson and Hussey, 1960). Each autumn larger lakes form loose brash ice during freezeup. This ice accumulates and moves until grounded along E and W shallows. Thus, freezeups further extend the season of differential erosion.

In shallow ponds where only 15-50 m (50-170 feet) of fetch is possible, wave action is minimal and

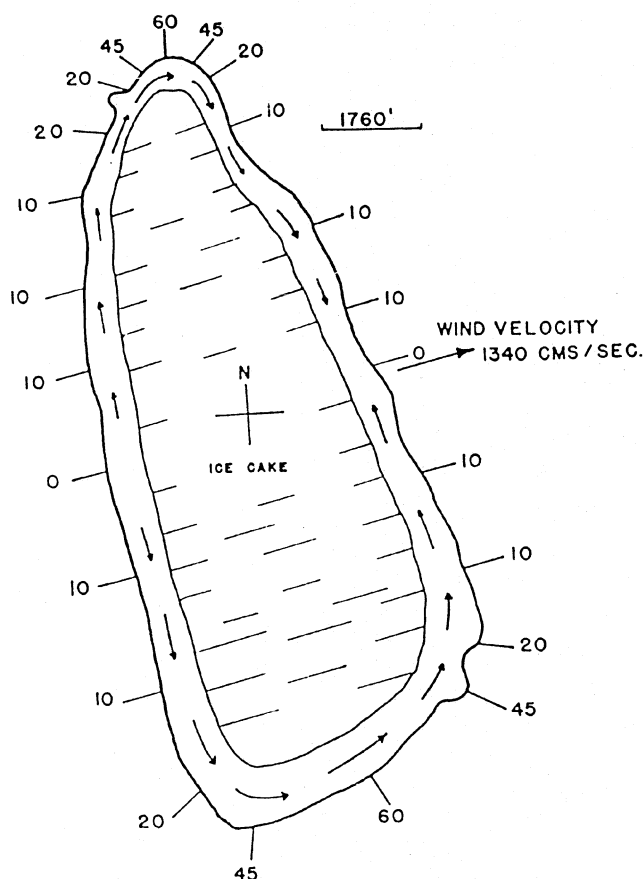


Fig. 11. Current velocities in the moat around Ikroavik Lake.

sediments are predominantly composed of light-weight peat particles. In these small ponds the current system proposed by Livingstone (1954) prevails and under a 670 cm/sec wind, maximum current velocities in the ends are windward on the order of 5-7 cm/sec. But later, in larger open lakes, just as predicted by Rex (1958; 1960), the general circulation is dominated by spiral cells in the ends driven by leeward littoral drift in the downwind corners. (Figs. 12-15). These cells reach maximum velocity and erosive power when wave crests form an angle of 50° with the shore at the downwind corners. In Ikroavik Lake, under a wind of 900 cm/sec maximum current velocities in the ends are on the order of 45-50 cm/sec. Higher wind velocities easily produce longshore currents of well over 100 cm/sec in these downwind corners. Thus, there is considerable erosive power concentrated in the ends of the larger lakes.

Just as with basin morphology and sediment distribution, the general patterns of circulation and wave action were carefully mapped and recorded for ponds and lakes of all sizes and depths. Air photos later confirmed that these circulation maps were accurate. The turbidity patterns show that maximum littoral drift is concentrated in the downwind corners and the current returned in a more diffuse and slower spiral toward the windward corners (Fig. 15).

CONCLUSIONS

Maps of both drained and water-filled basins combined with permafrost depth measurements in the bottom of the nearshore zone around all sides of present ponds and lakes show that the sides but not the ends are protected from thaw and erosion by the development of sub-littoral equilibrium profiles. In smaller ponds these profiles consist mainly of wave-drifted bars of peat particles and fine silts, but in the larger lakes they are wave-cut shelves mantled with silts and sands. Wave-drifted peat is confined along the shore where it acts as a buffer bar against wave action and as insulation over the permafrost below. In both ponds and lakes these shelf profiles have a wave-damping and permafrost-insulating effect along the sides, whereas their absence in the ends permits the unrestrained erosive action of waves, currents, and thaw. Consequently, there is a tendency for the lake basins to assume a wind-controlled uniform orientation. (See Fig. 16 a-c.)

By 1960 daily weather and climatic data at Barrow had been recorded for more than three quarters of a century. Analysis of these observations indicated that

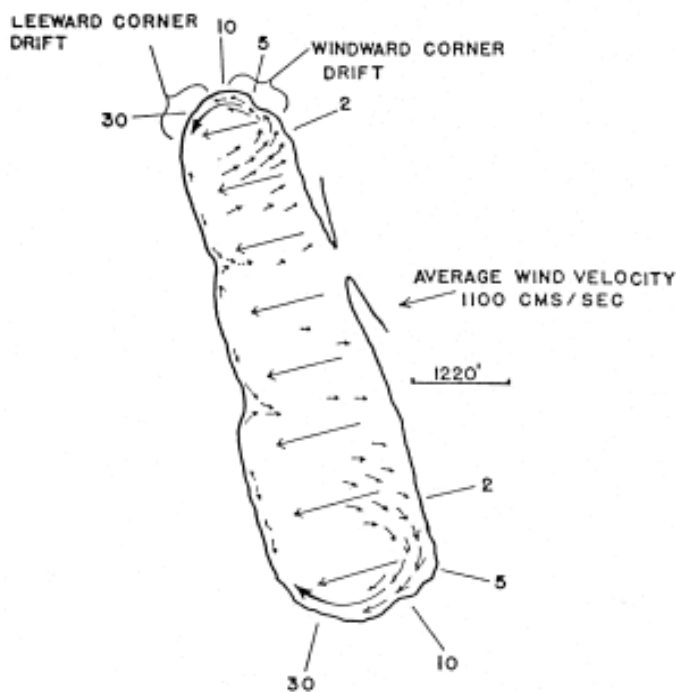


Fig. 12 - Current spirals in the ends of Loon Lake.

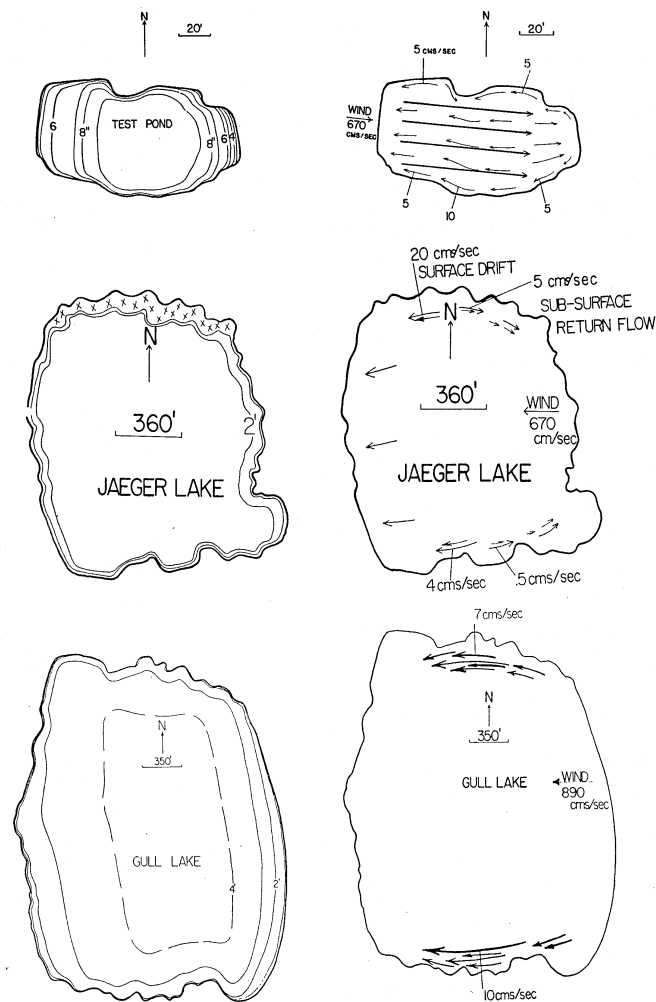


Fig. 13- Topographic basin maps and changing circulation patterns in lakes of increasing size.

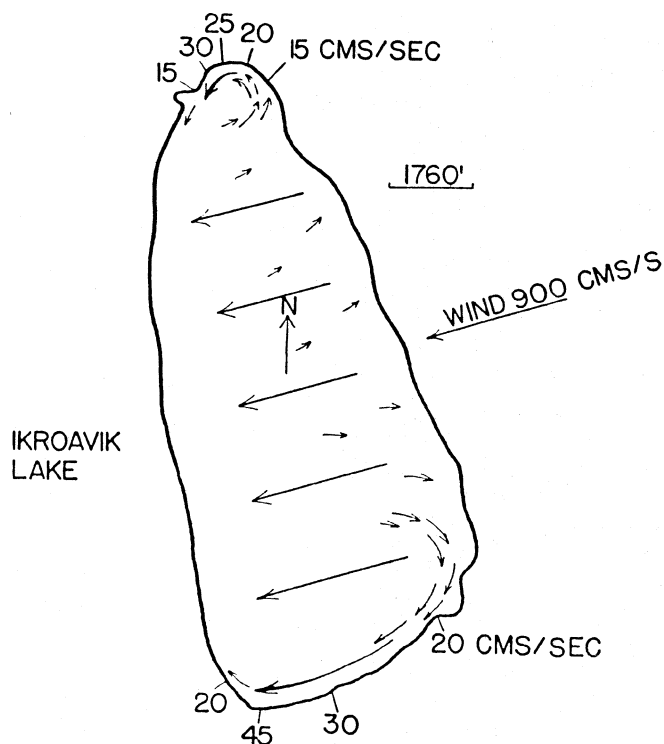


Fig. 14. - Current spirals in the ends of Ikroavik Lake.

the lake shelves along the east and west sides are oriented exactly perpendicular to the thaw season wind resultants. Both easterly and westerly wind resultants in the Barrow area form a large obtuse angle to the NNW (Fig. 17). Therefore, the protective shelf profiles gradually converge toward the NNW creating basins tapering northward, and restricting thaw and erosion there more than at the wider south ends. Thus, contrary to subjective impression, the lake basins probably expand more rapidly to the SSE than to the NNW.

Further examination of the weather data shows that during July and August there are also occasional strong

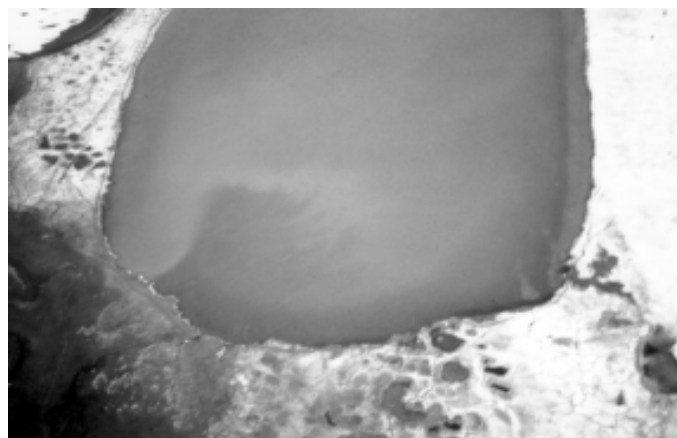


Fig. 15. Aerial photo of the south end of Loon Lake showing maximum turbidity in the zone of maximum littoral drift and the diffuse return spiral.



Fig. 16a. Wave damping effect of wave-drifted peat along the side of a thaw lake near Pt. Barrow.



Fig. 16b. A large wave-drifted peat bar in East Twin Lake southeast of Barrow.



Fig. 16c. Sandy shelves of a large recently drained lake basin southwest of Barrow.

NNW and NNE winds of short duration, which produce storm waves that sweep the long north-south fetches. These storms erode the south ends even more. The relative rarity of such storms, and the quick resumption

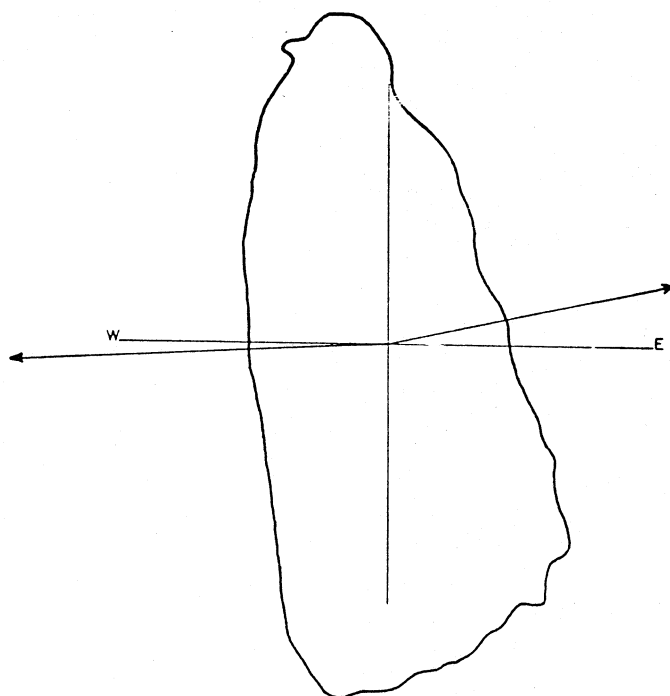


Fig. 17. - Resultant wind directions for the months of July and August, 1959. The areal outline of Woavik Lake is shown with respect to the coordinate system. It can be seen that the vectors are nearly perpendicular to the respective east and west shore line&

of the normal circulation pattern, precludes the formation of any permanent protective shelf profiles. Thus, once more it can be seen that even during unusual winds of short duration maximum erosion and thaw are consistently concentrated in the south ends of these lake basins.

To test hypotheses other than those involving wave and current action, trenches, auger holes, air photos, and maps were used to detect any possible fracture control in the permafrost of the underlying Gubik Formation, but none was found. Recording devices were made and used to detect and measure control of lake basin orientation by solar radiation, but it soon appeared that this idea too had little basis. Frequent cloud cover diffuses incident radiation, and removes any direct orienting influence from consideration.

The theoretical model suggested by Rex (1958; 1960) is basically correct for lakes if not for smaller ponds. As he pointed out, his model is complicated by irregularities in shoreline composition, basin history, and variations in the permafrost. The presence of ice-rich permafrost allows these endogenic thaw basins to grow, but the gradual accumulation of insulating sediment along the sides and in the bottoms, as well as intersection by streams, other thaw lakes, and the sea,

tends to limit their growth. My investigation offered a more complete picture of actual lake basin formation, but did not determine with statistical finality that ideal lake basin development in such a thaw situation is limited by a predictably changing depth-width ratio (Carson and Hussey, 1962).

CONFIRMATION AND FURTHER WORK

Field studies near Barrow were supplemented by additional investigations in the Kuparuk River region in the eastern section of the Arctic Coastal Plain. Numerous lakes and ponds of generally smaller size (Fig. 18) form in that region. Moreover, they taper to produce narrower ends to the south rather than to the north. Many have a greater length-width ratio than those near Barrow and are obviously relict lakes along the revegetated strands of larger drained lake basins. Yet, many others of the same general shape and orientation are not so long and thin. Most thaw ponds here are less than 1 m (3 feet) deep and so, like the small ponds near Barrow, contain bottom sediments primarily composed of organic matter. Just as at Barrow, this material forms a profile of wave peat and fine silts along the sides. The profile acts to insulate permafrost not found in the ends. Composition of the underlying parent formation also differs from that near Barrow. There is a higher calcium carbonate content and hence a light-colored marly (lime scum) coating of



Fig. 18. Oblique aerial view of small lakes and ponds pointing south near Kuparuk River.

bottom sediments, rather than the dark brown color seen at Barrow. In these clear, shallow ponds, this permits a better view of the bottom.

Examination of weather data from Barter Island, the nearest weather station to Kuparuk at the time, revealed

that, as at Barrow, prevailing summer winds are from the ENE and WSW. But, unlike those at Barrow the obtuse angle formed between wind resultants is to the SSE rather than to the NNW (Fig. 19). Therefore, the basins are likely to be growing to the NNW faster than to the SSE because protective profiles along the sides converge toward the SSE. This observation would confirm the analyses by Rex (1958; 1960), and the

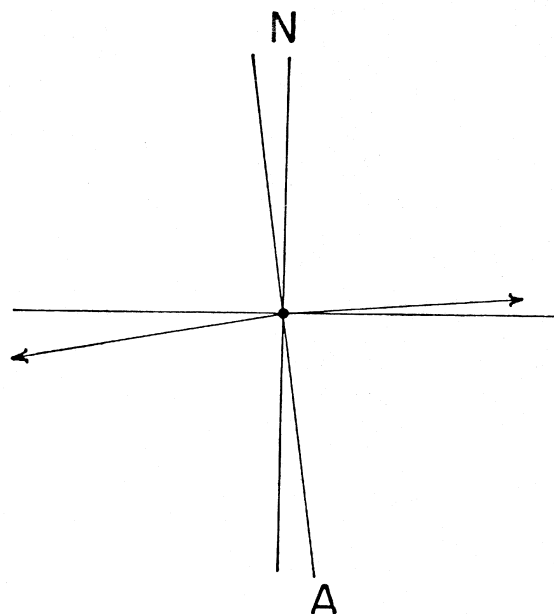


Fig. 19. - Wind resultants form an obtuse angle to the south in the Kuparuk River area.

Barrow observations of this study.

THE AGE OF RELICT STRANDS: preliminary indications

At the conclusion of the original project, another project was undertaken with support from AINA, ONR, and the University of Minnesota. Samples were taken from the base of the peat layer now covering mineral soils beneath several relict and revegetated lake basin sequences near Barrow. Thirty samples from five sequences were dated. These indicated that terrestrial vegetation (tundra) began to form peat on older strands less than 3500 years ago (Carson, 1968). Dates from the highest strands suggest that the oldest of several thaw-lake cycles may have begun when a number of basins drained 3500 to 4000 years ago (Fig. 1).

These ages may mean that a period of widespread basin drainage coincided with an episode of climatic cooling. With cooling, a succession of lower sea levels, and consequent headward erosion of streams, in turn,

could have initiated widespread simultaneous drainage of oriented lakes in the Arctic Coastal Plain. Preliminary radiocarbon studies have not been extensive enough, however, to permit correlation of the age of main strands with documented climatic trends and sea level changes during the Late Pleistocene.

Typical of scientific inquiry, this account ends on a tantalizing note. On one hand, endogenic (local, regional) mechanisms seem satisfactorily to explain the orientation of the thaw lakes we see today on the Arctic Coastal Plain. On the other hand, we can wonder about past thaw lake cycles. Do today's cycles, from birth through growth, to death to rebirth, trace their earliest origins to a distant (exogenic) triggering event, such as a drop in global sea levels 3500 years ago?

Knowledge of the Arctic Coastal Plan has increased so much since these investigations of 40 years ago that my conclusions now seem obvious and simple. Yet less was known then because detailed scientific examination of this difficult region was only just beginning. It is still far from comprehensive and complete. The NARL experience was most valuable not only for excellent logistical support under difficult frontier conditions, but for the wise and friendly counsel of Drs. Max Britton of ONR and Max Brewer, Director of the Lab in those years, and that of the Native personnel, particularly Ken Toovak and Pete Sovalik. Their cooperation and encouragement of innovation and multidisciplinary teams was invaluable. For me it was a unique broadening experience that I have found most helpful in what, somewhat later, became a greatly different professional life.

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Higher Fungi and Slime Molds from Arctic Coastal and Arcto-Alpine Tundra of Northern Alaska

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ABSTRACT: Two hundred twenty-nine species of Basidiomycetes within 78 genera representing ca. 35 families have been reported from Alaska's Arctic North Slope. The Ascomycetes number 147 species in 75 genera and ca. 40 families for a total of 376 species of higher fungi in 153 genera representing ca. 75 families that persist on Alaska's Arctic North Slope. This is a relatively conservative number as we know of other species that simply have yet to be fully worked up and published. For the slime molds, the Myxomycetes are represented by 37 species in 19 genera and 10 families; the Dictyosteliomycetes by just two species in a single genus and family; and the Protosteliomycetes are represented by only three species in three genera and one family for a total slime mold population of 31 species in 21 genera contained within ca. eight families for the same geographical region. A total of 407 species in 174 genera of ca. 83 families are herein presented as the most recent compendium of published records of fungi and slime mold species from high latitude arctic coastal and Arcto-alpine tundra in northern Alaska. Several taxa are reported from the region for the first time. These taxa are: *Clitocybe dealbata* (Sow.:Fr.) Kummer, *Conocybe* aff. *tenera* (Schaeff.:Fr.) Fayod, *Coprinus comatus* (Mull.:Fr.) S.F. Gray, *Hydropus scabripes* (Murr.) Singer, *Mycena alexandri* Singer, *Mycena avenaceae* (Fr.) Quel., *Mycena crispa* Kuhner, *Mycena epipterygia* (Scop.:Fr.) S.F. Gray var. *badiceps* M. Lange, *Mycena pseudocrispula* Kuhner, *Mycena pseudocrispata* Valla, and *Morchella angusticeps* Pk. for the fungi, and *Comatricha nigra* (Pers.) J. Schrt., *Diderma deplanatum* Fr., *Didymium difforme* (Pers.) Gray, and *Stemonitis fusca* Roth for the slime molds.

Key Words: Acrasiomycetes, Alaska, alpine, Arctic, Ascomycetes, Basidiomycetes, fungi, Myceteae, Myxomycetes, Protosteliomycetes, Protista, slime molds, tundra

INTRODUCTION

The study of US Arctic mycology has a brief history, less than 100 years. The first Arctic fungi were collected and briefly investigated during the Harriman Alaskan Expedition of 1899. Collections were passed on to three notable mycologists of the day, Pier Saccardo, Charles H. Peck, and William Trelease, who in 1904, published results of their findings. Only seven collections of higher fungi were described; however, all seven were coastal Arctic species of micromycetes, small and most often parasitic fungi. Listed were *Massarina dryadis* Rostr. on *Dryas integrifolia*, *Pleospora herbarum* (Fr.) Rab. on *Ranunculus nivalis*, *Septoria chamissonis* Sacc.:Scalia on *Eriophorum chamissonia*, *Sphaerella pachyasca* Rostr. on *Draba alpina* and reported later by Kobayasi et al. (1967) as *Mycosphaerelle tassiana*, *Stagonospora aquatica* var. *luzulicola* Sacc.:Scalia on *Luzula arctica*, and *Ustilago vinosa* (Berk.) Tul. on *Oxyria digyna*. Anderson (1940) lists two additional species in *Melampsora arctica* Rostr. on *Salix arctica* and *Puccinia conglomerata* (Strauss) Schm.:G. on *Petasites frigida*. G.A. Llano contributed to "A Checklist of Alaskan Fungi" (Cash 1953) which did include 13

species of fungi collected from Arcto-alpine tundra in the vicinity of Anaktuvuk Pass, some 160 miles SE of Barrow in the Brooks Mountain Province of North Slope Alaska. He listed two species on *Alnus* sp.; *Dothidella alni* Pk. and *Euryachora betulina* (Fr.) Schm. Eleven species of higher fungi were found in association with or on *Salix alaxensis*. They included *Calvatia cretacea* (Berk.) Lloyd, *Cytidia salicina* (Fr.) Burt., *Exidia glandulosa* Fr., *Hypoxylon blanckei* B:C, *Mollisia sublividula* (Nyl.) Karst., *Ozonium auricomum* Pk., *Polyporus elegans* Fr., *Rhytisma salicinum* Fr., *Solenia anomala* (Fr.) Fuckel, *Tricholoma ionides* (Fr.) Kummer, and *Valsa barella* Karst.

It wasn't until after the Naval Arctic Research Laboratory (NARL), located 6 km NE of the largest Eskimo village, Barrow, on Alaska's Arctic North Slope, was conceived in 1947, built to house and support US scientific expeditions in 1952, and then operated by US scientists through Office of Naval Research (ONR) by contract to the University of Alaska Fairbanks (UAF) in 1954 that mycological research commenced in the US High Arctic. It was Kobayasi et al. in 1965 who made the first "mycological pilgrimage" to Arctic Alaska and then published the results of that work wherein they listed 203 taxa (six of

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which were new to science) in 136 genera representing 61 families of fungi and one Myxomycete, *Lycogola epidendrum* (L.) Fries, in Kobayasi et al. (1967) and 97 taxa in 57 genera from 30 families to complete the workup of collections made in 1965 (Kobayasi et al., 1969). The higher fungi found in both reports are listed in Tables 1 & 2. Most species listed are micromycetes within the two Divisions of higher fungi. Others are found in the groups of lower fungi (Myceteae) and the water molds, Kingdom Chromista.

METHODS

Review of the literature from 1967 to 2000 revealed most of the referenced citations for the fungi and slime molds considered herein. Purposefully excluded were the microfungi considered to be soil inhabiting Zygomycetes, the imperfect Deuteromycetes, and the aquatic Chytridiomycetes and Oomycetes, of the Kingdom Chromista, once considered as 'fungi'. A report on these groups for northern Alaska is forthcoming. Where appropriate, synonyms are listed as these were the names used in the original literature before published name changes were conceived. Fungi referenced in this chapter that list no 'Reference' are documented for the first time from this region.

RESULTS AND DISCUSSION

With the onset of the International Biological (Tundra Biome) Programme (IBP-TB) conducted from the Naval Arctic Research Laboratory (NARL) during the period of 1969-74, another surge in mycological study occurred. Studies of soil fungi and fungal biomass in response to myriad environmental/ecological factors and the taxonomy of the fungi were undertaken by numerous investigators in Ammirati and Laursen (1982), Horak & Miller (1992), Kobayasi et al. (1967, 1969), Laursen (1975), Laursen and Ammirati (1982a, b, & c) (Figure 1), Laursen, Ammirati, and Farr (1987), Laursen, Ammirati, and Redhead (1987), Laursen and Burdsall (1976), Laursen and Chmielewski (1982), Laursen and Miller (1977a & b), Laursen, Miller, and Bigelow (1976), Miller (1982, 1987), Miller, Burdsall, Laursen, & Sachs (1980), Miller and Laursen (1974), Miller, Laursen, and Calhoun (1974), Miller, Laursen, & Farr (1982), Miller, Laursen, and Murray (1973), Miller, Laursen, and Murray (1974), Miller, Laursen, and Sachs (1974), and Petrini and Laursen (1993a & b). The NARL, operated by the Office of Naval Research through the prime contractor, the University of Alaska Fairbanks, closed its doors to general scientific support in 1980. The last scientific meeting conducted by the NARL was held in August of that year and is fondly remembered as the First

International Symposium on Arcto-Alpine Mycology (FISAM) with 24 international guest mycologists from nine foreign countries and the US (Fig. 1) (Laursen and Ammirati, 1982a). The FISAM acted as further impetus for a new wave of mycological investigations conducted from the mid 1980's to the mid 1990's, as is evidenced by the work of the present authors (Fig. 2).

Appendix Tables 1 and 2 summarize results of mycological investigations on higher fungi (Basidiomycetes and Ascomycetes) largely published during the period, 1965-1992. First records of several taxa in Northern Alaska are added here (Reference no. 51).

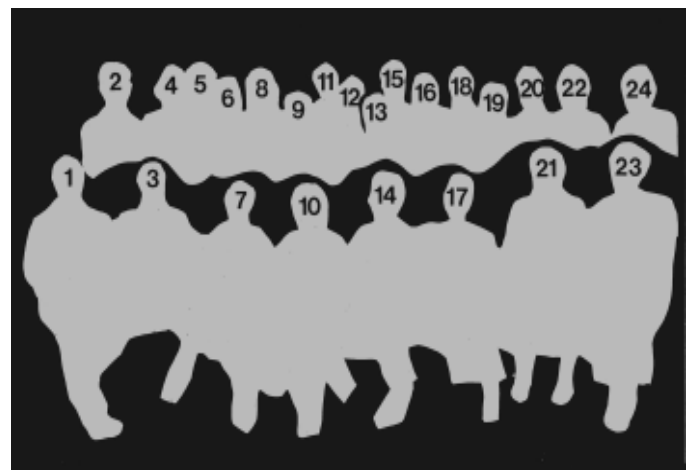


Fig. 1. Participants and contributors for the First International Symposium for Arcto-Alpine Mycology held at NARL in Barrow, AK. (L-R, 1-24) 1) Gary Laursen, 2) Joe Ammirati, 3) Terry Hall, 4) Henning Knudsen, 5) Pete Linkins, 6) Henry Dissing, 7) Heili Heikkilä, 8) Milan Petersen, 9) Morten Lange, 10) Bodil Lange, 11) Richard Korf, 12) Gro Gulden, 13) Yosio Kobayasi, 14) Denise Lamoure, 15) Orson Miller, 16) Sigmund Sivertsen, 17) Esteri Ohenoja, 18) Nils Fries, 19) Meinhard Moser, 20) Paavo Kallio, 21) Ben Rosey, 22) Doug Savile, 23) John Kelley, and 24) Egon Horak.



Fig. 2. The authors at Browerville, during an arctic collecting trip in 1992. (L-R): John Landolt, Gary Laursen and Steve Stephenson.

MYXOMYCETES: THE PLASMODIAL (TRUE) SLIME MOLDS

The distribution and ecology of myxomycetes, the true or plasmodial slime molds, from terrestrial ecosystems is based largely on studies conducted in temperate forests. Studies of myxomycetes from alpine and Arctic regions are few (Götzsche, 1989), but two studies by Stephenson and Laursen (1993, 1998) have provided information on northern Alaskan species. In general, the myxomycetes do not represent a conspicuous element in the biota of Arctic and alpine tundra plant communities, although a few species are sometimes found in amazing abundance after recent rains in certain microhabitats. Of the approximately 90 species reported for all of Arctic, Subarctic, and Alpine Alaskan tundra, and Boreal forest ecotones (Stephenson and Laursen 1998), fewer than 26 are truly inhabitants of high-latitude regions of northern Alaska. We find that these 26 species are grouped into 17 genera and six families (Appendix Table 3).

Ecological roles and dynamics of the myxomycetes, the plasmodial (true) slime molds associated with plant communities in high-latitude areas of North America, especially in the Arctic, are still poorly known. This is particularly true for Alaska, given its immense size and multiple life zones most generally referred to as the *Arctic*, north of the Brooks Mountain Range; *Interior*, between the Brooks Mountains to the north and the Alaskan Range (an extension of the Rocky Mountains) to the south; the Beringian Northwest and Southwest Arctic of *Western* Alaska; *South Central*/coastal Alaska, *South Eastern* Alaskan Panhandle; and the *Aleutian* Island chain with its maritime tundra.

Few reports on Alaskan myxomycetes have been made. Macbride (1899) reported six coastal SE Alaskan species. Saccardo et al. (1904) listed these and also

noted one additional species. Martin (1949) and Cash (1953) each added one new record. More recently Laursen and Chmielewski (1982), Blackwell (1984), Stephenson and Laursen (1993), Clark (1995), Stephenson and Laursen (1998) have listed species from Southeast, South-central, Western, Interior (subarctic), and Northern (Arctic) Alaska. A search of the National Fungus Collections (BPI) also turned up several additional collections from Alaska. The 90+ species thus far recorded represent field collections and fruitings from litter moist chamber cultures. As with the Basidiomycetes and Ascomycetes, the number of species recorded thus far for northern Alaska is likely to increase substantially with additional field work in the region.

ACRASIOMYCETES: THE DICTYOSTELID CELLULAR (FALSE) SLIME MOLDS

As described by Landolt et al. (1992), the dictyostelid cellular slime molds (DCSM) are single celled eukaryotic amoebocytes that are phagotrophic bacterivores usually present and often abundant in terrestrial ecosystems. These morphologically simple, but early successional pioneering organisms represent a normal component of the microflora of soils, are often present in relatively high numbers, and play a role in maintaining the natural balance that exists between resident bacteria and other micro-rhizospheric organisms within the microenvironmental humus/soil system (Raper, 1984; Landolt et al., 1992). The trophic stage of their life cycle consists of independent, assimilative amoeboid myxamoebae that feed upon bacterial populations, other microorganisms, grow, and multiply by binary fission. Upon depletion of microsite food supplies, the myxamoebae aggregate to form pseudoplasmodia wherein each amoeboid cell retains its integrity. This aggregated structure then goes on to differentiate into the "fungus-like" fructification, the sorocarp.

Previous studies on the distribution and occurrence of dictyostelid cellular slime mold species in different parts of the world, of which there are ca. 90 total species, indicate that species richness decreases with increasing elevation or latitude (Cavender, 1973; Raper, 1984). We find that two species in a single genus are frequently encountered in high latitude environments (Stephenson et al., 1991). Even though dictyostelid cellular slime mold communities associated with high elevation alpine tundra and high latitude subarctic and Arctic tundra sites demonstrate relatively low species richness, the few species that are present can occur in staggering numbers. Factors that contribute to low species richness are thought to include

moist to saturated tundra peat soils where anaerobic conditions can exist near the surface, organic soils sometimes poor in bacterial substrates, and low soil temperatures (Appendix Table 4). The two species reported from northern Alaska are cosmopolitan. Several additional species are known from the subantarctic interior and Western Alaska (Stephenson et al., 1997).

PROTOSTELIOMYCETES: THE PROTOSTELIDS

Protostelids are a group of simple slime molds that produce microscopic fruiting bodies, each bearing one or two spores at the tip of a delicate, acellular stalk (Spiegel, 1990). Because of their very small size, protostelids are known only from laboratory cultures. Although unknown to science until 1960, these organisms are thought to be ubiquitous in terrestrial ecosystems. However, ecological studies of the group are few. Virtually all of the information available on the occurrence and distribution of protostelids has been derived from studies carried out in temperate regions of eastern North America (e.g., Baker, 1975; Best and Spiegel, 1984; Moore and Spiegel, 1995). In the first study of the protostelids associated with the plant communities found at high latitudes, Stephenson et al. (2000) reported three species from Arctic montane tundra north of Atigun pass in the Brooks Range (Appendix Table 5). In this study, protostelids were isolated from samples of aerial litter (dead but still attached plant parts), using a modification of the technique described by Olive (1975). Five additional species are known from subarctic interior and western Alaska (Stephenson et al., 1999).

SUMMARY

A total of 407 species in 174 genera of ca. 83 families of Basidiomycetes, Ascomycetes, Myxomycetes, Acrasiomycetes, and Protosteliomycetes are herein represented as the most recent compendium of published records of fungi and slime mold species from high latitude coastal arctic and alpine tundra in northern Alaska. Several taxa are presented here for the first time. These taxa include *Clitocybe dealbata* (Sow.:Fr.) Kummer, *Conocybe* aff. *tenera* (Schaeff.:Fr.) Fayod, *Coprinus comatus* (Mull.:Fr.) S.F. Gray, *Hydropus scabripes* (Murr.) Singer, *Mycena alexandri* Singer, *Mycena avenaceae* (Fr.) Quel, *Mycena crispa* Kuhner, *Mycena epipterygia* (Scop.:Fr.) S.F. Gray var. *badiceps* M. Lange, *Mycena pseudocrispula* Kuhner, *Mycena pseudocrispata* Valla, and *Morchella angusticeps* Pk. for the fungi, and *Comatricha nigra* (Pers.) J. Schrt., *Diderma deplanatum* Fr., *Didymium difforme* (Pers.) Gray, and *Stemonitis fusca* Roth for the slime molds.

FUTURE RESEARCH

The value of our updating the regional taxonomic inventory here is that it lays the foundation for biogeographic syntheses. We foresee that synthesis first involves understanding the processes by which fungi have infiltrated cold-dominated habitats above Latitude 66° 33' N. Subsequently, and no less importantly, synthesis should address the potential influence that global warming would have on the dispersal of fungi in high latitudes. Some hypothesize that gradual warming will produce greatest effects at higher latitudes where vast reservoirs of carbon-based peat have accumulated. Decomposer fungi could release globally significant volumes of carbon dioxide by their biological degradation of these substrates. Warming may result in greater taxonomic diversity among the fungi, making it imperative that baseline and inventory studies continue.

Stages in synthesis must deal with the various life cycle strategies and ecological niches or roles manifested by the fungi enumerated in Appendix Tables 1-5. These roles include: occupying highly specific niches (e.g. mycorrhizal and parasitic fungi); operating as decomposers of native arctic and subarctic substrates; searching out, selecting, and destroying woody substrates; migrating opportunistically using roots of higher plants to form many rather plastic mycorrhizal associations; and forming diverse lichen associations (Fig. 3) that feature combinations of many different mycobionts (species of fungi) with relatively few taxa of photobionts (algae and cyanobacteria).



Fig. 3. *Omphalia umbellata*

A cosmopolitan basidiolichen (a lichenized fungus) found in the subantarctic, the subarctic, Arctic, and Appalachian Mountains.

We illustrate some directions and limitations that future biogeographic synthesis efforts face, by discussing higher fungi (Divisions Ascomycetes and Basidiomycetes). Speciation, endemism, and fungal relationships to substrates (wood, graminoids, roots, and living plant tissues) show several patterns. Apart from lichenized fungi, we can generalize broadly that there are fewer genera and species of fungi in maritime, montane/alpine, Arctic, subarctic, and subantarctic tundras than are found at middle and low latitudes. Substantially fewer vascular plant species are available as substrates at the highest latitudes. Barrow's flora includes 125 vascular species, and 3-4 times that number of fungal species. At Atqasuk on the Meade River there are about 225 vascular species, and fungi number 4-5 times that. Along the 100-km Barrow-Atqasuk transect there are also significant shifts in the roles that these fungi play: as the number of woody substrates increases, the number of decomposer and mycorrhizal species also increases. Likewise the number of parasitic ascomycetous fungi within the transitional Taiga to the more substantial boreal conifers and broad-leaved deciduous species continues to increase. Ratios of fungal to vascular plant species (F:VP) increase at progressively lower latitudes (from 2-3:1 in the High Arctic, 3-4:1 in the Low Arctic, 4-6:1 in the subarctic, 8-9:1 in deciduous forests, and to about 12:1 in tropical forests). The lack of complete inventories of fungi for any of these regions explains uncertainties in these F:VP ratios, and underscores the need for mycological taxonomy and inventories that use modern tools (DNA, isozymes) to discern species complexes.

Endemic species of Basidiomycetes are probably rare because many are circumpolar in their distribution (especially bryicolous species or fungi parasitic on endemic vascular plants). By contrast, endemism is more common among the Ascomycetes, especially the parasitic forms, reflecting greater host-specificity. Other higher fungi are shown to be rather cosmopolitan in that their substrates are universal. Members of decomposer groups, whose spore dispersal depends upon winds or clouds aloft, tend to belong to this cosmopolitan group. On subantarctic islands we have found virtually no ectomycorrhizae nor basidiomes of representative species, so many of which are Basidiomycetes. Because of what we see, we speculate that most species of higher fungi in arctic regions of North America probably emanated from northerly ranging "biological bridges" possessing cool or cold dominated climates within tundra or tundra-like settings. These bridges include the Rocky Mountains that arch

westward to terminate in central Alaska, and the east-west ranging Bering Land Bridge (Beringia). Evidence suggests that disjunct relict populations of "Arctic fungi" persist in the Cascades, Sierra Nevada, and even the Appalachian Mountains. Similarly, populations of "Arctic fungi" are to be expected throughout the Central European Alps. Birds and wind probably aid in spore dispersal of these species. Mycorrhizal, and especially some ectomycorrhizal species of fungi, tend not to be dispersed by birds or wind. These forms whose basidiomes are subterranean (hypogeous) are common in the subarctic, rare in the Arctic (Fig. 4), and virtually absent in the subantarctic. It has been hypothesized that many of these fungi depend on rodents for vectoring spores, but no systematic studies show that these gut-treated spores consistently germinate to produce viable sporocarps. We see in this question a ready-made undertaking for a student in Mammalogy, Mycology, or Ecology.



Fig. 4. *Geopora cooperi forma cooperi*

*A hypogeous Ascomycete (true truffle) of conifer forests traditionally, but whose plastic ectomycorrhizal association permits association with Arctic willow species (*Salix alaxensis*) and whose dispersal is thought most likely to be vectored by rodents.*

Arctic mycology has attracted career dedication by relatively few researchers, perhaps because of the region's harsh habitats and study conditions. Nevertheless, in the 30-year period of studies, 1971-2000, we submit that NARL's support of descriptive phases in arctic mycology has helped the field to establish a sound basis and rationale for continuing analysis and synthesis.

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Appendix: Table 1. Taxa of Basidiomycete Fungi reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska. Nomenclature follows Singer (1976). Table follows the format of **Taxon/Author(s) : citation # (s) for distribution** (see References above).

- Amanita inorata* Secr. :34
Amanita regalis (Fr.) Michael :29
Amanita vaginata (Bull.:Fr.) Quel. :12
Amanita vaginata (Fr.) Vitt. :29
Antrodia stereoides (Fr.) Bond.:Sing. :12
Arrhenia auriscalpium Fries :17
Boletus edulis Bull.:Fr. :12, 22, 29
Botrydina botryoides (L.) Redhead & Kuyper
 (= *Omphalina ericetorum* (Fr.) M. Lange) :17, 22, 29
Botrydina viridis (Ach.) Redhead & Kuyper
 (= *Omphalina hudsoniana* (Jenn.) Bigelow)
 :17, 22, 29
Botrydina luteovitellinia (Pilát & Nannf.) Redhead
 & Kuyper
 (= *Omphalina luteovitellinia* (Pilát & Nannf.)
 M. Lange :17, 22
Bovista sp. :22
Calvatia arctica Ferd. & Winge :22
Calvatia cretacea (Berk.) Lloyd :6, 12, 22, 29, 31
Calvatia tatrensis Hollis :22
Chrysomyxa empetri Schroeter: Cummins :13
Chrysomyxa ledicola Lagerheim :13
Cintractia caricis (Pers.) Magnus :12
Clavariadelphus borealis Wells & Kempton :29
Clavariadelphus pistilaris (Fr.) Donk :12
Clavulina cristata (Fr.) Schroet. :22
Clavulinopsis arctica Y. Kobayasi :12
Clitocybe angustissima (Lasch) Fr. :12
Clitocybe dealbata (Sow.:Fr.) Kummer :51
Clitocybe multiceps Peck :12
Collybia cirrhata [Schum.] Quel. :12
Collybia incrustata O.K. Miller :29
Conocybe aff. tenera (Schaeff.:Fr.) Fayod :51
Coprinus angulatus Peck :12
Coprinus atramentarius (Bull.:Fr.) Fries :12
Coprinus comatus (Mull.:Fr.) S.F. Gray :51
Coprinus cordisporus Gibbs :34
Coprinus ephemerus Fr. :12
Coprinus lagopus Fr. :12
Coprinus martinii Favre:Orton :17, 22, 34
Coprinus aff. patouillardii Quel.
 (= *C. cordisporus* Gibb.) :22
Coprinus velox Godey :12
Corticium sp. :12
Cortinarius (Dermocybe) sp. :17
Cortinarius alpinus Boud. :12, 17
Cortinarius anomalus (Fr.:Fr.) Fries :1
Cortinarius cinereoviolaceus (Fr.) J. Lange :12, 17
Cortinarius decoloratus Fries :12
Cortinarius delibutus Fries :1, 17
Cortinarius favrei Moser:Henderson :1, 17, 22
Cortinarius mucosus (Bull.:Fr.) Kickx. :1, 22, 29
Cortinarius aff. mucosus (Fr.) Fries :1
Cortinarius aff. multififormis (Fr.) Fries :1
Cortinarius obtusus (Fr.) Fries :1
Cortinarius subtorvus Lamoure :1, 17, 22
Crucibulum vulgare Tul. :12
Cyphellopsis anomala (Fr.) Donk :12
Cystoderma amianthinum (Fr.) Fayod :12
Cystoderma amianthinum (Fr.) Fayod
 var. *amianthinum* (Scop.:Fr.) Fayod :17, 22,
 35
Cystoderma fallax Smith & Singer :17, 22
Cystoderma tuomikoshii Harmaja :17
Cytidia salicina (Fr.) Burt :6, 12
Dacryomyces deliquescens (Merat) Duby :12
Dacryomyces ellisii Coker :12
Entoloma sericium (Bull.:Merat) Quel. :17, 22, 29
Excidia glandulosa Fr. :6, 12
Exobasidium angustisporum Linder :13
Exobasidium vaccinii (Fuckel) Woronin
 var. *myrtilli* (Fuckel) Juel :13
Exobasidium vaccinii-uliginosi Boudier :12, 13
Flamulina velutipes (Fr.) Karst. :22
Galerina arctica (Singer) Nezdjminogo :11
Galerina clavata (Velenovsky) Kuhner :11
Galerina heterocystis (Atk.) Smith & Singer :17, 22
Galerina hypnorum (Schränk:Fries) Kuhner :11
Galerina hypophaea Kuhner :17
Galerina leptocystis Wells & Kempton :11
Galerina macrospora (Velen.) Singer :17, 22
Galerina mniophila (Lasch.) Kuhner :17, 22
Galerina moellerii Bas :17, 22
Galerina pseudocerina Singer & Smith :11
Galerina pseudomycenopsis Pilát & Nannfeldt :11
Galerina praticola (Moeller) Orton :22
Galerina pumila (Pers.:Fr.) M. Lange :17, 22
Galerina pumila var. *subalpina* Smith :17
Galerina stordalii Smith :17, 22
Galerina subanulata (Singer) Smith & Singer :11,
 35
Galerina subarctica Smith & Singer :11
Galerina viscida (Peck) Smith & Singer :17
Gerronema marchantiae Sing. & Clem. :17, 22
Gerronema pseudogrisellum (Smith) Gulden &
 Lange :17
Glabrocypella sp. :12
Hebeloma kuhneri Bruchet :17
Hebeloma marginatulum (Favre) Bruchet :22
Hebeloma pusillum J. Lange :17, 22, 35
Hebeloma subconcolor Bruchet :17

- Hohenbuehelia longipes* (Boud.) Moser :22
Hydropus scabripes (Murr.) Singer :51
Hygrocybe citrinopallida Smith & Hesler :12, 17, 19, 34
Hygrocybe coccineocrenata (Orton) Moser :19
Hygrocybe aff. *lilacina* (Laest.) Moser :19
Hygrocybe miniata (Scop.:Fr.) Karst :12, 34
Hygrocybe conica (Scop.:Fr.) Kummer :19, 22
Hygrocybe vitellina Fries :17
Hygrophorus chrysodon (Fries) Fries :19, 29
Hygrophorus aff. *eburneus* (Bull.:Fr.) Fries :19, 29
Hygrophorus laetus (Fr.) Fries :19, 29
Hygrophorus lilacinus (Laest.) M. Lange :12
Hygrophorus melizeus (Batsch:Fr.) Fries :19, 29
Hygrophorus vitellinus Fries, sensu Moeller :12
Hymenochaete tabacina (Fr.) Lev. :12
Hypholoma sp. :17
Hypholoma ericaeoides Orton :17
Hypholoma myosotis (Fr.) Moser
 (= *Naematoloma myosotis* (Fr.) Smith)
 (= *Pholiota myosotis* (Fr.) Singer) :17, 22, 34
Hypholoma udum (Pers.:Fr.) Kuhner
 (= *Naematoloma udum* (Pers.:Fr.) Karst. :17, 22, 34, 35
Inocybe boltoni Heim ssp. *giacomii* (Favre) O.K. Miller :30
Inocybe borealis M. Lange :22
Inocybe decipientoides Peck :22, 35
Inocybe dulcamara (Fr.) Quel. :22
Inocybe lacera (Fr.) Kummer :17
Laccaria sp. :17
Laccaria laccata (Scop.) Berk.:Br.
 var. *proxima* (Boud.) Maire :12
Laccaria proxima (Boud.) Pat. :29
Laccaria striatula (Peck) Peck :17, 22
Laccaria tetraspora Singer :12, 29, 34
Laccaria tortilis (Bolt.:S.F. Gray) Cke :22, 34
Laccaria tortilis [Secretan] Boud. :12
Lactarius aff. *aspideoides* Burl. :17
Lactarius aff. *aspideus* (Fr.) Fries :17
Lactarius deliciosus (Fr.) S.F. Gray :17
Lactarius glyciosmus (Fr.) Fries :17
Lactarius lanceolatus Miller & Laursen :17, 22, 29, 34, 35
Lactarius pallidus (Pers.) Fries :12
Lactarius aff. *pubescens* Fries :17
Lactarius pubescens Fries :17, 22, 29
Lactarius aff. *pyrogalus* (Fr.) Fries :17
Lactarius repraesentaneus Britz. :17, 22
Lactarius resumus (Fr.) Fries :29
Lactarius salicis-herbaceae Kuhner :22
Lactarius scrobiculatus (Fr.) Fries :17
Lactarius aff. *subcircellatus* Kuhner :22
Lactarius subcircellatus Kuhner :17
Lactarius subresimus O.K. Miller :29
Lactarius tabidus Fries :12
Lactarius thejogalus (Fr.) S.F. Gray :12, 17
Lactarius torminosus (Schff.:Fr.) S.F. Gray :22, 29
Lactarius torminosus (Schff.:Fr.) S.F. Gray
 var. *torminosus* :17
Lactarius trivialis (Fr.) Fries :17
Lactarius uvidus (Fr.) Fries :17
Lactarius vietus (Fr.) Fries :17
Leccinum scabrum (Bull.:Fr.) S.F. Gray :12, 17
Lentaria mucida (Fr.) Corner :12
Lepiota echinella Quel.
 var. *eriophora* (Peck) J. Lange :12
Lepista multiformes
 (= *Clitocybe polygonarum* Laursen, Miller & Bigelow) :17, 25
Leptoglossum littoralis Hojland :17
Leptoglossum lobatum (Pers.:Fr.) Ricken :17, 22
Leptoglossum muscigenum (Fr.) Lundell :12
Leptonia sp. :22
Lycoperdon pyriforme var. *tesselatum* Pers. :29
Lycoperdon umbrinum Pers. :12, 22
Lyophyllum connatum (Schum.:Fr.) Singer :17
Marasmius androsaceus (L.) Fr. :12
Marasmius epidryas Kuhner :29
Marasmius siccus (Schw.) Fries :22
Melampsora arctica Rostrop :2, 12
Melampsora bigelowii Thumen :12, 13
Melanoleuca sp. :22
Melanoleuca borealis Gillman & Miller :10, 29
Melanoleuca tanana Gillman & Miller :10, 29
Multiclavula muscida (Fr.) Petersen :22
Mycena alexandri Singer :51
Mycena avenaceae (Fr.) Quel :51
Mycena crispa Kuhner :51
Mycena epipterygia (Scop.:Fr.) S.F. Gray :17, 22
Mycena epipterygia (Scop.:Fr.) S.F. Gray
 var. *badiceps* M. Lange :51
Mycena epipterygia (Scop.:Fr.) S.F. Gray
 var. *brunneola* Favre :34
Mycena galericulata (Scop.:Fr.) S.F. Gray :22
Mycena pseudocrispula Kuhner :51
Mycena pseudocrispata Valla :51
Mycena pura (Pers.:Fr.) Kummer :22
Naematoloma squamosum (Pers.:Fr.) Singer :12
Noleana sp. :22
Odontia cristulata Fr. :12
Omphalina brownii (Bk. & Br.) Orton :17
Omphalina obscurata Reid :17
Omphalina pyxidata (Bull.:Fr.) Quel. :17, 22
Omphalina umbratilis Fr. var. *minor* Fr. :12
Omphalina velutipes Orton :17
Ozonium auricomum Pk. :6
Panaeolus acuminatus (Schff.:Secr.) Quel. :17, 22

Table 1. Taxa of Basidiomycete Fungi reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska (Continued).

Panaeolus subbalteatus (Burk & Br.) Sacc. :34
Peniophora aurantiaca (Bres.) Hohn.:Litsch. :12
Peniophora violaceo-livida (Sommerf.) Masee :12
Phaeogalera stagnina (Fries) Pegler & Young
 (= *Galerina stagnina* (Fr.) Kuhner) :11, 17, 22
Pholiota sp. :12
Pistillaria sp. :12
Pleurotus sp. :12
Polyporellus elegans (Bull.:Fries) Karst
 (= *Polyporus elegans* Bull.:Fries) :6, 12, 17
Psathyrella atomata (Fr.) Quel. :12
Psilocybe sp. :17
Psilocybe atrorufa (Schaeff.) Fries :12
Psilocybe montana :34
Pucciniastrum pyrolae Dietel:Arthur :13
Puccinia arnicalis Peck :13
Puccinia asteris Duby :12
Puccinia bistortae de Candolle :13
Puccinia conglomerata (Strauss) Rohling :2, 12, 17
Puccinia coronata Corda :13
Puccinia cruciferarum Rudolph :13
Puccinia heucherae (Schw.) Dietel
 var. *saxifragae* (Schlecht.) Savile :12, 13
Puccinia millefolii Fuckel :13
Puccinia oxyrae Fuckel :13
Puccinia polemonii Dietel:Holway :13
Puccinia pulsatillae Kalchbrenner :13
Puccinia rhytismoides Johanson :13
Puccinia sieversiae Arthur :13
Puccinia ustalis Berkeley :12
Puccinia volkartiana Ed. Fischer :12
Russula sp. :17
Russula alpina (Blytt) Moeller & J. Schff. :17
Russula compacta Frost. :22
Russula emetica Schaeff.:Fries
 var. *alpestris* (Boud.) Singer :22, 29, 35
Russula delica Fries :12
Russula fragilis (Pers.) Fries :12
Russula aff. *foetens* (Fr.:Pers.) Fries :22
Russula nana Killerm. :17, 22
Russula nitida Fries :12
Russula subalpina O.K. Miller :29
Russula xerampelina Schff.:Fries
 var. *pascua* Moeller & Schaeff. :22, 35
Sebacina arctica Y. Kobayasi :12
Solenia anomala (Fr.) Fuckel :6
Thekopsora sparsa (Wint.) Magnus :12
Thelephora anthocephala Bull.:Fries :12, 22
Thelephora terrestris Ehrh.:Fries :22
Tricholoma ionides (Fr.) Kummer :6

Tubaria furfuracea (Pers.:Fr.) Gill :29
Uromyces hedysari-obscuri (D.C.) Leveille :13
Uromyces lapponicus Lagerheim :12
Ustilago vinosa (Berk.) Tul. :44

Table 2: Taxa of Ascomycete Fungi reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska. Table follows the format of **Taxon/Author(s) :citation #s for distribution (see References above).**

Aleuria aphanodictyon Y. Kobayasi :12, 13, 17
Aleuria rhenana Fckl. :17
Ascobolus brunneus Cooke :13
Ascobolus doliiformis Y. Kobayasi :12
Ascobolus geophilus Seaver :13
Ascobolus stercorarius (Bulliard) Schroeter. :12
Ascobolus wineri Rehm :13
Calosphaeria arctica Otani :13
Calycella sp. :13
Calycella citrina (Hedw.:Fr.) Boudier :12
Calycellina sp. :12
Cenangium arcticum (Ehrenb.) Fries :12
Chaetomium circinatum Chivers :13
Chaetomium funicola Cooke :12
Cladobotryum varium
 (annomorph to *Hypomyces aurantius*) :17
Chlorociboria aeruginascens (Nyl.) Kanouse :13
Coniochaeta discospora (Auerswald) Cain :12
Coniochaeta leucoplaca (Berk.:Rav.) Cain :13
Coniochaeta saccardoi (Marchal) Cain :13
Cryptococcus albidus (Saito) Skinner :12
Cryptococcus diffulens (Zack)
 Lodder:Kregervan-Rij :12
Cryptococcus laurentii (Kauf.) Skinner
 var. *magnus* Lodder:Keger van-Rij :12
Cryptococcus luteolus (Saito) Skinner :12
Cryptococcus terreus Di Menna :12
Cudoniella stagnalis (Quel.) Sace :12, 22
Dasyscyphus sp. :13
Delitschia bisporula (Crouan) Hansen :12
Dothidella almi Pk. :6
Euryachora betulina (Fr.) Schm. :6
Fimaria porcina Svr.:Kub. :12
Gelasinospora tetrasperma Dowding :13
Geotrichella arctica Tubaki :22
Helvella corium (Weberb.) Massie :17, 22
Hymenoscyphus conscriptus (Karst.) Korf :12, 13
Hypospila sp. :12
Hypospila rhytismoides (Babingst) Niessl. :12
Hypoxylon blanckei B.:C. :6
Hypoxylon fuscum [Pers.] Fries :12
Hysteropezizella sp. :12
Hysteropezizella diminuens (Karst.) Nannfeldt :13

- Iodophanus carneus* (Pers.) Korf :13
Karschia lignyota (Fr.) Sacc. :12
Lachnellula sp. :17
Lasiobolus ciliatus (Schmidt:Fr.) Boudier :12
Lasiobolus equinus (Mull.) Karst. :13
Leotia sp. :22
Leptosperia sp. :12
Leptosperia arcto-alaskana Y. Kobayasi :12
Leptosperia caricinella Karst. :13
Leptosperia dolioloides Auersw. :13
Leptosperia doliolum (Pers.) Ces.:de Not. :13
Leptosperia insignis Karst. :13
Leptosperia lycopodina (Mont.) Sacc. :13
Leptosperia millefolii (Fuckel) Niessl :13
Leptosperia nigrans (Desm.) Ces.:de Not. :13
Leptosperia ogilviensis (Berk.:Br.) Ces.:de Not. :13
Leptosperia silenae-acaulis de Notaris :12, 13
Leptosperia stellariae Rostrup :13
Leptosperia wustoma (Fr.) Sacc. :13
Leptothyrium arcticum (Fckl.) Lind :17
Lophoderma cladophilum (Lev.) Rehm. :12
Massarina dryadis Rostr. :44
Mollisia sublividula (Nyl.) Karst. :6
Morchella angusticeps Pk. :51
Mycocalicium sp. :13
Mycosphaerella lycopodii (Peck) House :13
Mycosphaerella maculiformes (Pers.:Fr.) Schroet. :13
Mycosphaerella minor (Karst.) Johans. :13
Mycosphaerella pyrenaica (Speg.) von Arx :13
Mycosphaerella ranunculi (Karst.) Lind :13
Mycosphaerella recutita (Fr.) Johans. :13
Mycosphaerella tassisna (de Notaris) Johanson :12
Mycosphaerella tassisna (de Notaris) Johanson
var. *arctica* (Rostr.) Barr :13
Mycosphaerella tassisna (de Notaris) Johanson
var. *tassiana* Barr :13
Myriosclerotinia sulcata (Whetz.) Buckwald :12, 22
Octospora leucoloma Hedwig:S.F. Gray :12
Octospora 'metachromatica' Korf :13
Octospora tetraspora (Fckl.) Korf :12
Oidium aff. *polygona* D.C. :12
Onygena corvina Alf. & Schw. :Fries :22
Orbilina coccinella (Sommerf.) Fries :12
Paxina acetabulum (L.:Fr.) Kuntze :22
Peziza sp. :22
Peziza cfr. *irrorata* Berk.:Cust. :12
Peziza limosa (Grelet) Nannfeldt :12
Phaeangellina empetri (Phillips) Dennis :13
Phaeotrichum aff. *Hystericinum* :12
Pleospora ambigua (Berl.:Bres.) Wehmeyer :13
Pleospora chlamydospora Sacc. :13
Pleospora coloradensis Ellis:Everhart :13
Pleospora comata Awd.:Niessl :13
Pleospora eocoronis (Clem.) Wehmeyer :13
Pleospora heleocharidis Karst
var. *arctica* (Karst) Wehmeyer :13
Pleospora heleocharidis Karst
var. *heleocharidis* Wehmeyer :13
Pleospora helvetica Niessl :13
Pleospora herbarum (Fr.) Rabenh. :13, 44
Pleospora longispora Speg. :13
Pleospora lutea Wehmeyer :13
Pleospora moravica (Petr.) Wehmeyer :13
Pleospora njegusensis Bubak :13
Pleospora penicillus (Schm.) Fuckel :13
Pleospora pentamera (Karst.) Wehmeyer :13
Pleospora punctiformis Niessl :13
Pleospora scrophulariae (Desm.) Hoehn. :13
Pleospora tragacanthae Rabenh. :13
Pleurage minuta (Fckl.) Kuntze
f. *tetraspora* (Winter) C. Moreau :12
Podospora tetraspora (Winter) Cain :13
Podospora vesticola (Berk.:Br.) Cain:Mirza :13
Propolis versicolor (Fr.) Fries :12
Psilopezia sp. :12
Pulvinula constellatis (Berk.:Br.) Boudier :12
Pyrenopeziza artemisiae (Lasch) Rehm :13
Pyrenopeziza potentillae (Rostr.) Nannf. :13, 17
Pyrenophora androsaces (Fckl.) Sacc. :12
Pyrenophora chyrsospora (Niessl.) Sacc.
var. *polaris* Karst. :12
Pyrenophora aff. paucitricha :12
Rhodotorula glutinis (Fres.) Harrison :12
Rhodotorula rubra (Dumme) Lodder :12
Rhytisma sp. :17
Rhytisma salicinum Fries :6
Saccobolus depauperatus (Berk.:Br.) E.C. Hansen :12
Saccobolus violascens Boud. :13
Schizothyrium sp. :12
Scutellinia scutellata (L.:Fr.) Lambotte :12, 22
Scutellinia trechispora (Berk.:Br.) Lambotte :12
Septoria chamissonis Sacc.:Scalia :44
Septoria eriophorella Sacc.:Scalia :44
Sepultaria arenosa (Fckl.) Boudier :12
Shanorella aff. *spiratricha* R.K. Benjamin :12
Sordaria arctica Cain :13
Sordaria humana (Fckl.) Winter :12, 13
Sordaria macrospora Auerswald :13
Sphaerotheca fuliginea (Schlecht.) Pollacci :13
Sporormia intermedia Auerswald :12

Table 2: Taxa of Ascomycete Fungi reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska (Continued).

Sporormia octomera Auerswald :12
Sporormiella intermedia (Auersw.) Ahmed:Cain :13
Sporormiella octomera (Auersw.) Ahmed:Cain :13
Stagonospora aquatica
 var. *luzulicola* Sacc.:Scalia :44
Tapesia sp. :12
Thelebolus crustaceus (Fckl.) Kimbrough :12
Thelebolus microsporus (Burk.:Br.) Kimbrough :12
Torulopsis gropengiesseri (Harrison) Lodder :12
Trichodelitschia bisporula (Crouan) Munk :13
Tympanis alnea (Pers.:Fr.) Fries :12
Valsa barella Karst. :6
Vibrissea sporogyra (Ingold) Sanchez :12
Wettsteinia eucarpa (Karst.) Moeller: von Arx :13

Table 3: Taxa of Myxomycetes reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska. Nomenclature follows that of Martin and Alexopoulos (1969). Table follows the format of **Taxon/Author(s)/:citation #(s) for distribution (see References above)**. BPI=Beltsville's "Bureau of Plant Industry"

Comatrigha nigra (Pers.) J. Schrt. :51
Diderma deplanatum Fr. :51
Didymium difforme (Pers.) Gray :51
Arcyria cinerea (Bull.) Pers. :6, 26, 50
Arcyria denudata (L.) Sheldon :6, 26, 50
Arcyria incarnata (Pers.) Pers. :BPI
Arcyria pomiformis (Leers) Rostaf. :50
Badhamia obovata :BPI
Ceratiomyxa fruticulosa (O.F. Muell.) Macbr. :6, 26, 50
Diderma effusum (Schw.) Morgan :50
Diderma niveum (Rostaf.) Macbr. :6, 44
Didymium dubium Rostaf. :6, 27, BPI
Didymium melanospermum (Pers.) Macbr. :BPI
Echinostelium minutum de Bary :49, 50
Fuligo intermedia Macbr. :5, 22, 49
Fuligo septica (L.) Wiggers :6, 9, 50
Hemitrichia serpula (Scop.) Rostaf. :49, 50
Leocarpus fragilis (Dicks.) Rostaf. :49, 50
Lycogala epidendrum (L.) Fries :12, 49, BPI
Macbrideola macrospora (Nann.-Brem.) Ing :49, 50
Metatrichia vesparium (Batsch) Nann.-Brem. :49, 50
Mucilago crustacea Wiggers :5, 22, BPI

Table 3: Taxa of Myxomycetes reported from Arctic

Coastal and Arcto-alpine tundra in northern Alaska (Continued).

Oligonema schweinitzii (Berk.) Martin :49, 50
Perichaena chrysosperma (Curry) A. Lister :49, 50
Perichaena depressa Libert :49, 50
Perichaena vermicularis (Schw.) Rostaf. :49, 50
Physarum sp. :22
Physarum bivalve Pers. :49
Physarum notabile Macbride :BPI
Physarum oblatum Macbride :49
Stemonitis axifera Bull.) Macbride :BPI
Stemonitis fusca Roth :51
Stemonitis smithii Macbride :6, 26, 50
Trichia contorta (Ditmar) Rostaf. :49, 50
Trichia favoginea (Batsch) Pers. :49, 50
Trichia flavicoma (A. Lister) Ing :50
Trichia lutescens (A. Lister) A. Lister :50
Trichia scabra Rostaf. :6, 26, 50
Trichia subfusca Rex :49
Tubifera ferruginosa (Batsch) Gmel. :6, 26, 50.

Table 4: Species of Acrasiomycetes (Dictyostelids) reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska. Nomenclature follows that of Raper (1984). Table follows the format of **Taxon/Author(s)/:citation #(s) for distribution (see References above)**.

Dictyostelium aureo-stipes Cavender, Raper, & Norberg :48
Dictyostelium gigantium Singh :7
Dictyostelium minutum Raper :48
Dictyostelium mucoroides Brefeld :7, 47
Dictyostelium sphaerocephalum [Oud.] Sacc.:March :7, 47
Polysphondylium pallidum Olive :14.

Table 5: Species of Protosteliomycetes (Protostelids) reported from Arctic Coastal and Arcto-alpine tundra in northern Alaska. Nomenclature follows Raper (1984). Table follows the format of **Taxon :citation # for distribution (see References above)**.

Nematostelium gracile :39
Schizoplasmodiopsis pseudoendospora :39
Trichosporium acutostipes :39

Snow and Ice Research Begun at and Continued from NARL

Carl S. Benson¹

ABSTRACT: On Alaska's Arctic Slope snow covers the surface for about 3/4 of every year, and has a profound influence on the physical and biological characteristics of the region. Melting of this snow in the spring is the most significant hydrological event of the year; it is responsible for half of the total stream runoff. The quantity of snowfall has been reassessed and found to be about three times more than measured by standard, unshielded precipitation gages. The structure of the snow pack has been measured and a profound difference exists between the veneer of snow on the tundra and the deeper, denser, and harder snow in drifts. Knowledge of the flux of wind blown snow is important for engineering purposes such as keeping snow from drifting into selected areas and depositing snow in other areas to serve as a water supply. We have measured this flux by using natural drift traps. During the course of a winter, the prevailing easterly winds transport about 70 tonnes per lineal meter, normal to the wind. The westerly storm winds transport about half this amount. In the Northern foothills of the Brooks Range, katabatic winds transport snow from the south; the boundary between the southerly transport and the east-west transport is only roughly known now. These studies of seasonal snow, began at NARL in 1961 and are still underway. The McCall Glacier Project, begun during the IGY (1957) and continued to the present, constitutes the longest record of an Arctic Glacier in the U.S.; it is a valuable site for measuring the integrated effect of changes in climate.

Key words: snow, snow drifting, McCall Glacier, Arctic Slope, Wyoming snow gage, precipitation measurements

INTRODUCTION

In the Northern Hemisphere seasonal snow is the most changeable surface feature that affects the overall reflectivity of Planet Earth in its interactions with the sun. In the Southern Hemisphere, this role is played by sea ice. A fresh snow surface has an albedo (ratio of reflected energy to incident energy in the visible portion of the spectrum) of 80% whereas the albedo of bare tundra or open water is 20% or less. On Alaska's Arctic Slope, snow covers the surface for most of the year. It is subjected to significant transport by the wind and must be dealt with by every plant and animal that calls the place home. This paper summarizes some research on snow and ice that was supported at ARL and NARL, beginning in 1961. It also indicates problems that are still being addressed. But we start by indicating how the Arctic Slope snow fits in with the world of snow.

Alaska is virtually a made-to-order snow laboratory because it contains maritime, continental, and Arctic climates in proximity. Striking differences exist in the snow cover from one climatic region to the next. This fortuitous situation is the result of two sharply defined climatic boundaries that cross Alaska:

- (1) The Alaskan coastal ranges separate the North Pacific Maritime Climate from a severe Continental Climate.
- (2) The Brooks Range separates the interior Continental Climate from the Arctic Polar Basin Climate.

Each of the three climatic regions contains its own characteristic snow cover (Pruitt, 1970; Benson, 1967; 1969; 1982):

“tundra snow” in the Arctic,
“taiga snow,” in the Interior and,
“maritime snow” in the Pacific coastal mountains.

In addition to the three major climatic types, a fourth, the Transitional Zone, lies south of the Alaska Range and is transitional between the Interior and Maritime zones. Climatic conditions alternate between continental and maritime. In the interior this transitional zone becomes apparent as one progresses westward toward the Bering Sea, especially west of Koyukuk (about 158°W) on the Yukon-Kuskokwim delta. Here, the temperatures and winds are higher than farther east and the climate becomes more maritime; many snow storms are mixed with rain and the snow cover is characterized by significant amounts of icing with depth hoar at the bottom. The snow cover is transitional between the three major types but no special name is applied to it.

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Tundra snow, found mainly on the Arctic slope, lasts for nine months, is wind-packed, dry, and sastrugi-sculptured, with depth hoar at its base. *Taiga snow*, found mainly in the taiga, between the Brooks and Alaska Ranges lasts for slightly more than 6 months. Its most notable physical characteristic is the low-density ($<0.2 \text{ g}\cdot\text{cm}^{-3}$, e.g. grams per cubic centimetre) loosely consolidated, depth hoar which makes up most of the snowpack in the lowland brush and forest areas. *Maritime snow*, found in the coastal mountains and lowlands of southeastern and south central Alaska is often deeper than 10 m and may be wet at low altitudes; snow temperatures are significantly higher than in tundra or taiga snow.

Since 1961 we have been doing research on the snow of interior and arctic Alaska; and this paper deals primarily with the Arctic Slope.

TUNDRA SNOW AND TAIGA SNOW

Tundra and taiga snow share properties that differ from those in snow of temperate latitudes, primarily due to temperatures, and temperature gradients in the snow pack. In temperate latitudes, where most people live, temperatures at the base of the snow pack are often at or near the melting point, and temperature gradients within the snow are weak. The snow cover protects the underlying soil from drying and can serve as a source of moisture. If there is a flux of water at the soil-snow interface it is from the snow downward to the soil. In tundra snow of the Arctic and taiga snow of the subarctic, the situation is reversed; the snow-soil temperature is well below the melting point and strong temperature gradients persist for 150 to 200 days. This situation produces an upward flux of water vapor within the snow and from the soil below. The underlying soil and vegetation undergo a freeze-dry process, and lose moisture to the overlying snow.

Tundra and taiga snow also differ from the Alaska's maritime snow, which resembles maritime snow of the Pacific Coast all the way to the Sierra Nevada Mountains of California. Maritime snow nearly always has melting point temperatures at the base and weak temperature gradients within it. Thus, tundra and taiga snow are special because snow temperatures are lower, steeper temperature gradients occur in it, and there is less of it per unit area. Moreover, these types last longer and enter more directly into biological and human activities as snow itself, rather than serving primarily as a cold storage water reservoir.

Sturm and others (1995) summarize the difference between tundra, taiga, and maritime snow by showing the temperature at the base of the snowpack through the winter (Fig. 1). In maritime regions the basal temperature remains at or near the melting point because the deep snow remains relatively warm. In Alaska's Interior, when air temperatures drop below -40°C , freezing soil beneath the snow releases latent heat as soil freezes and maintains the snow-soil interface temperature in the range of -3° to -5° . In the Arctic where the substrate is permafrost, the active layer freezes by the end of October whereupon no more latent heat is available, so temperatures at the base of the snow can go much lower.

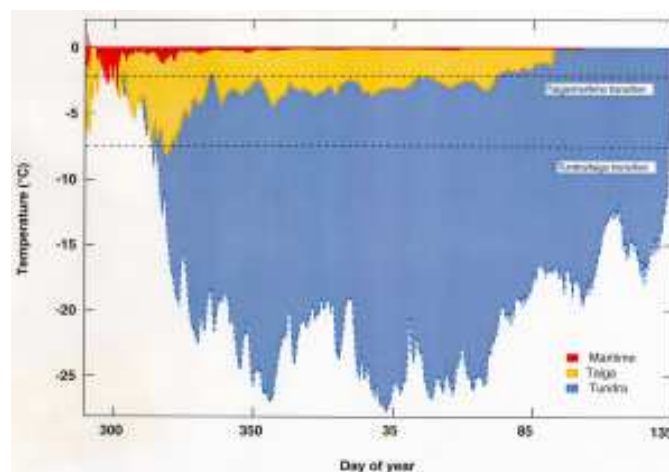


Fig. 1. Snow-soil interface temperatures, contrasted among maritime, taiga, and tundra systems in Alaska. (Sturm and others 1995)

ALASKA'S ARCTIC SLOPE

Aside from the perennial snow on glaciers, snow lasts longest on the Arctic Slope, nearly three-fourths of the year, and exerts a profound influence on the physical and biological characteristics of the region. Melting of this snow in the Spring is the most significant hydrological event of the year. The snow melt takes only about two weeks, once it gets underway, yet the time when this occurs can be anywhere within a 6 week period in May and June. Snowmelt decreases the albedo (the amount of solar energy reflected at the surface) by a factor of four (from 80% to 20%), and accounts for more than half of the stream runoff on the Arctic Slope (Hinzman, and others, 1996). Furthermore, the accompanying four-fold increase in the amount of energy absorbed at the surface, happens when the incoming solar radiation is near its maximum value. This produces a burst of biological activity, but because the melt takes place so close to summer

solstice, virtually the entire growing season takes place while the incoming solar radiation is decreasing (Fig. 2). Nevertheless, small animals, such as lemmings, spend most of their life cycle under snow, deriving from it protection from heat loss and from predators. Large animals, such as caribou and muskoxen have developed ways of traveling over snow and locating food sources beneath it. The interactions of mammals and snow were studied extensively by Pruitt (1970).

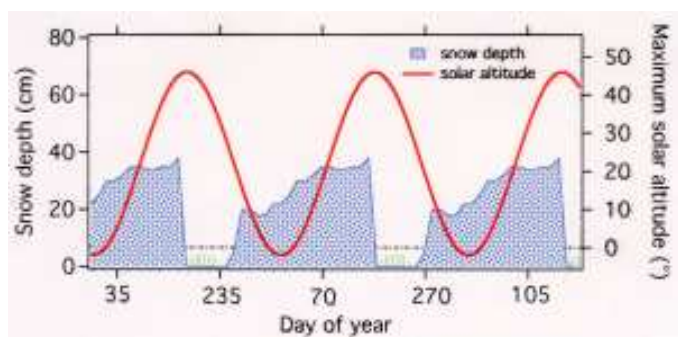


Fig. 2. Solar maximum values shown for several annual cycles, combined with a typical snow cover. (Snow measurements from 1970-71 winter, measured by D. Trabant.) See DIngmman and others 1980.

In spite of the importance of snow to the region, we find questions that need attention including:

How much snow falls on the Arctic Slope?

What is its water equivalent?

What fraction of the total precipitation comes as snow?

How accurately has the quantity of snowfall been measured?

How accurately can we measure it?

How much is moved by the winds?

—how far does it go?

—in which directions?

Is the drift pattern the same from year-to-year?

How much is lost by evaporation as it is blown about?

—as it melts?

Can we detect earlier snowmelt as a result of changes in the climate?

Figure 3 (Benson, 1982) identifies a few critical parameters:

P is the total amount of precipitation (mm water equivalent) which comes as snow.

P_t is the amount remaining on the tundra after some wind erosion.

P_r is the amount relocated by the wind.

Q is the total winter flux of snow transported by

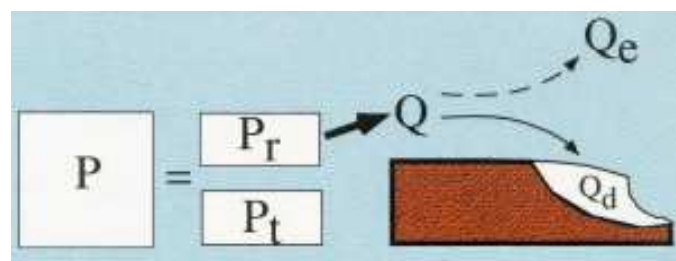


Fig. 3. Definition of terms for snow accumulation and redistribution.

wind in metric tonnes per metre width normal to the wind.

Q_e is the amount of Q lost by sublimation during or after transport.

Q_d is the amount of Q which is deposited in drifts.

A significant fraction of the total snow precipitation (P) is relocated by wind (P_r). Part of the relocated snow is lost in transport by sublimation (Q_e) and part is concentrated in drifts (Q_d). The part lost by sublimation remains to be determined, but the part which is deposited in drifts has been measured in selected “drift traps” which are natural features, such as river banks and bluffs oriented normal to the wind. These are discussed below. We shall discuss these terms, beginning with the complexities of measuring precipitation which comes at low temperature, often at low rates and in windy conditions.

PRECIPITATION DATA

The measurement of precipitation (P) which comes as snowfall presents a serious problem, especially in windy regions. Places like Alaska’s Arctic Slope and wind-swept Wyoming are notoriously difficult. The available information on winter precipitation on the Arctic Slope comes from two U.S. Weather Bureau Stations, One at Barrow (begun in 1922 and still in operation), and one at Barter Island (begun in 1949 and terminated in 1989).

Unfortunately, the U.S. Weather Bureau records underestimate snow precipitation on the Arctic Slope because of problems inherent in the measurement technique. Robert Black (1954) first pointed out the problem of underestimating precipitation as snowfall (P) at Barrow. One source of the erroneously low values of winter precipitation on the Arctic Slope is the use of unshielded rain gages to measure the snow. This is interesting in light of research on shielding gages, which has gone on for many years (Brooks, 1938; Warnick, 1953). I plotted the cumulative precipitation against time for the stations at Barrow and Barter

Island (Benson, 1982). The cumulative curve had some breaks in slope, for example. The slope in this curve showed a precipitation rate of 86 mm/year for 1925 to 1942, 153 mm/year from 1955 to 1966, and 96 mm/year from 1966 to 1979. If one were to interpret these changes in rate of precipitation as arising from climate changes, a serious error would be made. Closer inspection revealed that each major change in precipitation rate was associated with a change in the location of the gage, its shielding, or both.

Measurement of snow on the tundra showed that P , the total precipitation of snow at Barrow, was less than P_t for 1949-50 when Black first measured it. The Weather Bureau gage record was best during years of heavy precipitation, but it was always less than what was measured on the tundra, i.e., P_t . Yet the value for P_t itself must be less than P because of the fraction, P_r , relocated by the wind.

Another contribution to error is the low rate of snowfall combined with winds which cause many entries of “trace” in the record (Jackson, 1960). At Barrow and Barter Island on Alaska’s Arctic Coast the winter precipitation record contains many days during which trace is the only entry. During the calendar year 1978 at Barrow there were 282 days with recorded precipitation, but 192 of these days (68%) showed only “T” (for trace). These 192 entries of T add up to zero mm in the annual precipitation record. The size of error introduced by this practice is unknown. For the 7-year period, 1972 to 1979, I found an average of 63% and 64% trace in the records for Barrow and Barter Island respectively. In the 1973-1974 winter at Barter Island, trace made up 80% of the daily entries of precipitation records (Benson 1982).

Although trace is important, the main error in the record is because the gage always catches less than the true precipitation. There have been a number of attempts to develop shielding for precipitation gages, as mentioned above. Among the most successful are the gages shielded by the Wyoming Blow-Fence, (Fig. 4) developed in Wyoming by Rechar and Larson (1971). The first Wyoming gage on the Arctic Slope was built in 1975 at Atkasuk, by the Geophysical Institute of the University of Alaska, and the second at NARL. These gages, and others built by the Geophysical Institute, CRREL, U.S. Forest Service (USFS), and the Soil Conservation Service (SCS), U.S. Department of Agriculture, have all been turned over to the SCS (renamed the Natural Resources Conservation Service—NRCS) for long-term maintenance and operation.



Fig. 4. Wyoming Blow Fence at Barrow, Alaska.

It was an obvious opportunity to compare estimated snowfall by gages shielded by the Wyoming Blow Fence at Barrow and Barter Island with the Standard Weather Bureau gages for the four years 1975-1979. The Wyoming gages caught an average of 3.5 times more snow at Barrow and 2.6 times more at Barter Island (Benson, 1982). Based on data provided by G. Clagett of NRCS, and from the paper by Clagett and others (1983), Figure 5 shows the comparison of Wyoming gages with unshielded gages at Barrow and Barter Island for 1976 to 1987. Figure 6 compares snow on the tundra with shielded and unshielded gages at Barrow for the years 1977, 1978, and 1983; and Figure 7 shows the record for Barter Island in 1983, the worst case so far.

By measuring the snow on the tundra, attempting to correct for traces, and using the Wyoming gages, I reassessed the snowfall at Barrow and Barter Island to be about 80% of the total annual precipitation, with the totals nearly the same as the total for Fairbanks. For Barrow, snow was 195 mm, rain was 53 mm and total was 248 mm. For Barter Island the respective numbers were: snow 252, rain 66 and total 318 mm (Benson 1982). As pointed out by Yang and others (1998) the corrections must be made on daily values and the long-term corrections are open to question. Nevertheless, they confirmed that errors introduced by unshielded gages are the most important.

DRIFT TRAPS

Beginning in 1961, I had the good fortune of working with ARL’s Chief Pilot, Bobby Fisher, in selecting several sites for long-term observations of the snow cover. We flew over vast areas, and landed many times, in seeking representative areas to measure and study snow on the tundra, (P_t) and in snow drifts (Q_d).

An important factor in selecting a drift trap in which to measure the flux of drifted snow is to find one that does not “fill.” When a trap fills the snow can blow across it without being deposited. If a drift forms on a structure big enough so that the trap cannot fill then all of the snow blowing past it will be deposited in the

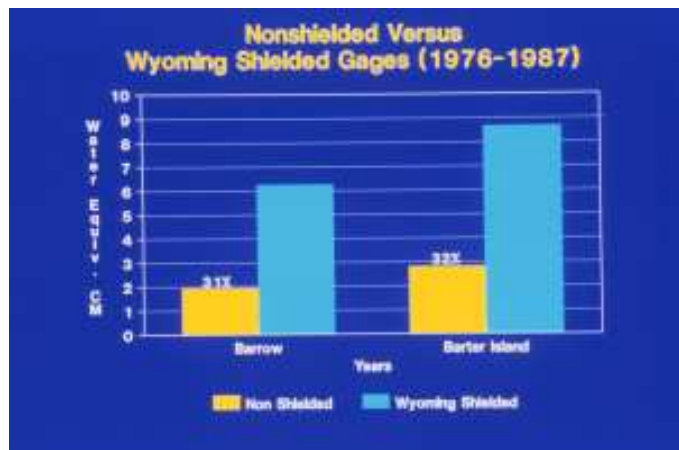


Fig. 5. Shielded and unshielded gauge data compared from Barrow and Barter Island (Kaktovik) from 1976 to 1987.



Fig. 6. Unshielded and shielded gauge and tundra snow at Barrow for 1977, 1978, and 1983.

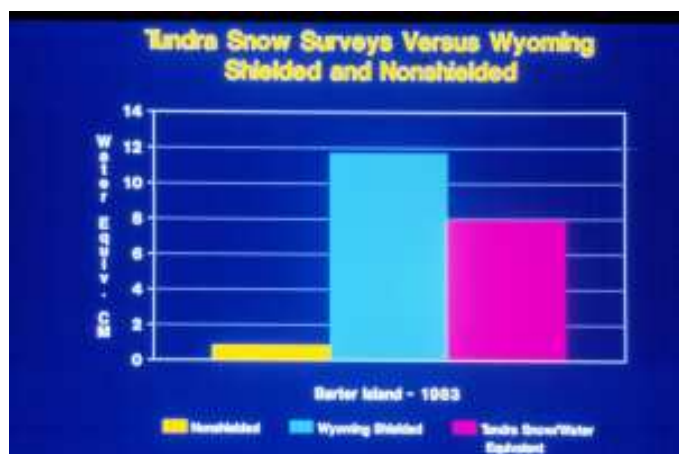


Fig. 7. The record at Barter Island, 1983.

drift. In such a case, the volume of snow measured in the trap at the end of winter is a measure of the net flux of snow blown from a given wind direction. The banks, selected by Fisher, on the Meade River in the Atkasuk area, about 95 km SSW of Barrow, are ideal in this sense. The one nearest the village forms a drift from the West winds and a large bank about five kilometres upstream on a meander which forms a drift from the East winds (Fig. 8). These are large drifts, formed on banks that are 10-20m high. They are measured in units of metric tonnes of snow per metre, normal to the wind. From 1962 to 1979, the prevailing winds from the East averaged about 70 tonnes and storm winds from the West winds averaged about 30 tonnes. Figure 9 summarizes the measurements made during the 1960s and 70s; numerical values for each year were presented by Benson and Sturm (1993). In addition to these winds, which predominate on the Arctic Coastal Plain, katabatic winds extend northward from the Brooks Range. To measure drifts from these winds, we selected north-facing bluffs in the northern foothills of the Brooks Range at Imnavait Creek, near Toolik Lake about 200 km south of Prudhoe Bay, Alaska. These bluffs trap snow from southerly winds, and in the same units used for the Atkasuk drifts, they averaged about 20. There is a wide variation in each of these values. The two sets of drift traps highlight the major wind regimes of the Arctic Slope of Alaska. We are still working to define the northern boundary of wind transport from the south, and to estimate wind transport of snow from wind speed records. In the early 1960s our goal was to measure the amount of snow on the tundra, and the direction and extent of snow drifting. What we started then has continued to the present with the structure of the snow being measured in two basic settings: the veneer of snow on the tundra and the snow in deep drifts (Benson and Sturm 1993).



Fig. 8. Mead River drift from east winds.

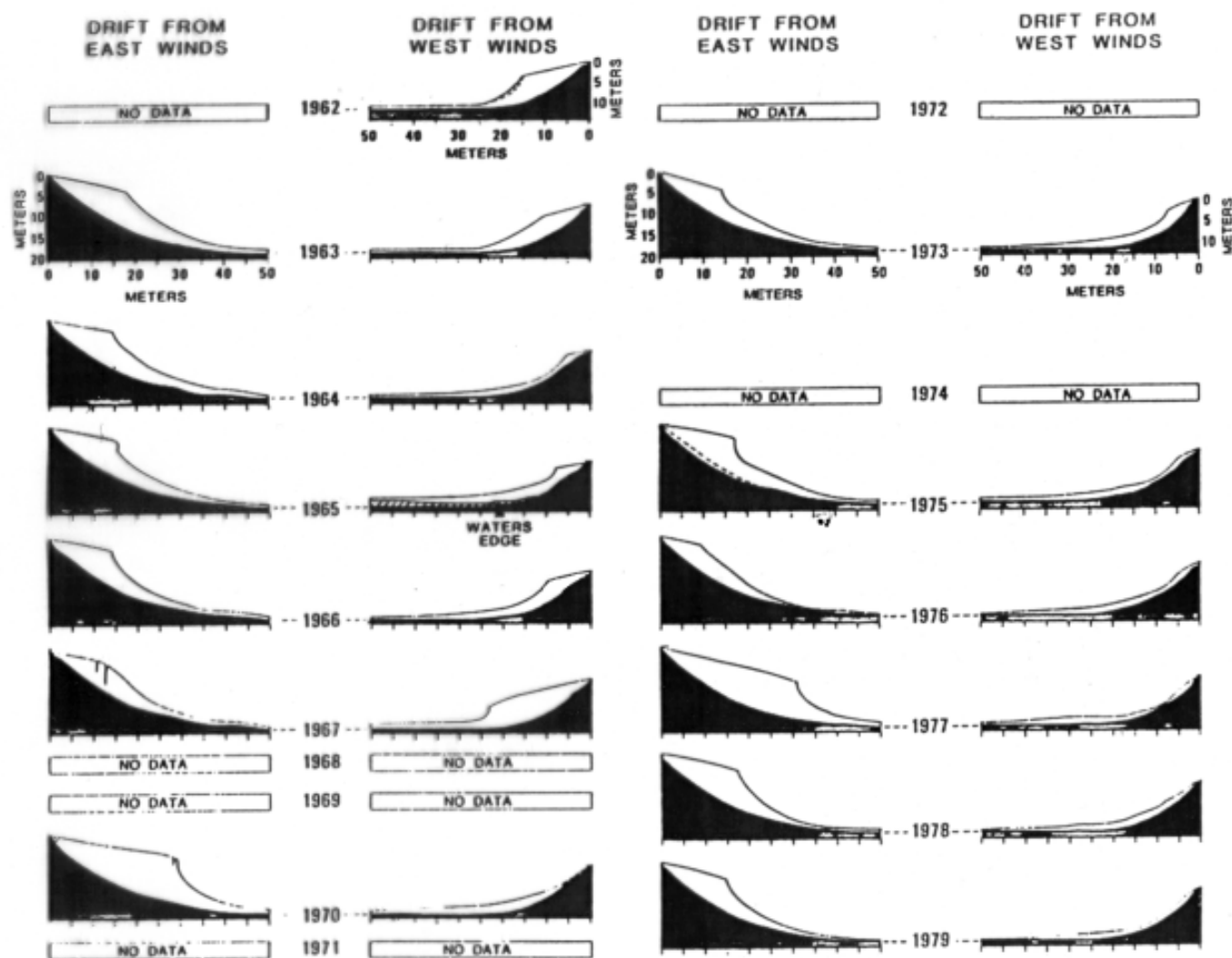


Fig. 9. Drift profiles from east and west winds measured at the river bluffs at Atqasuk on the Meade River, approximately 100 km SSW of Barrow. Cross-sections are viewed from the north (Benson and Sturm, 1993).

A key to studying the snow was to recognize that the pattern of snow distribution was essentially the same year after year even though the quantity varied. Fisher knew this and his experience was of utmost importance in selecting useful drift traps. We used this principle to help map the snow in detail on the tundra near Toolik Lake at Imnavait Creek (Fig. 10). It is obviously impossible to map at this detail over a large area, so the application of patterns was extended and applied to mapping snow distribution on a regional scale where detailed measurements are not possible (König, 1997; König and Sturm, 1998).

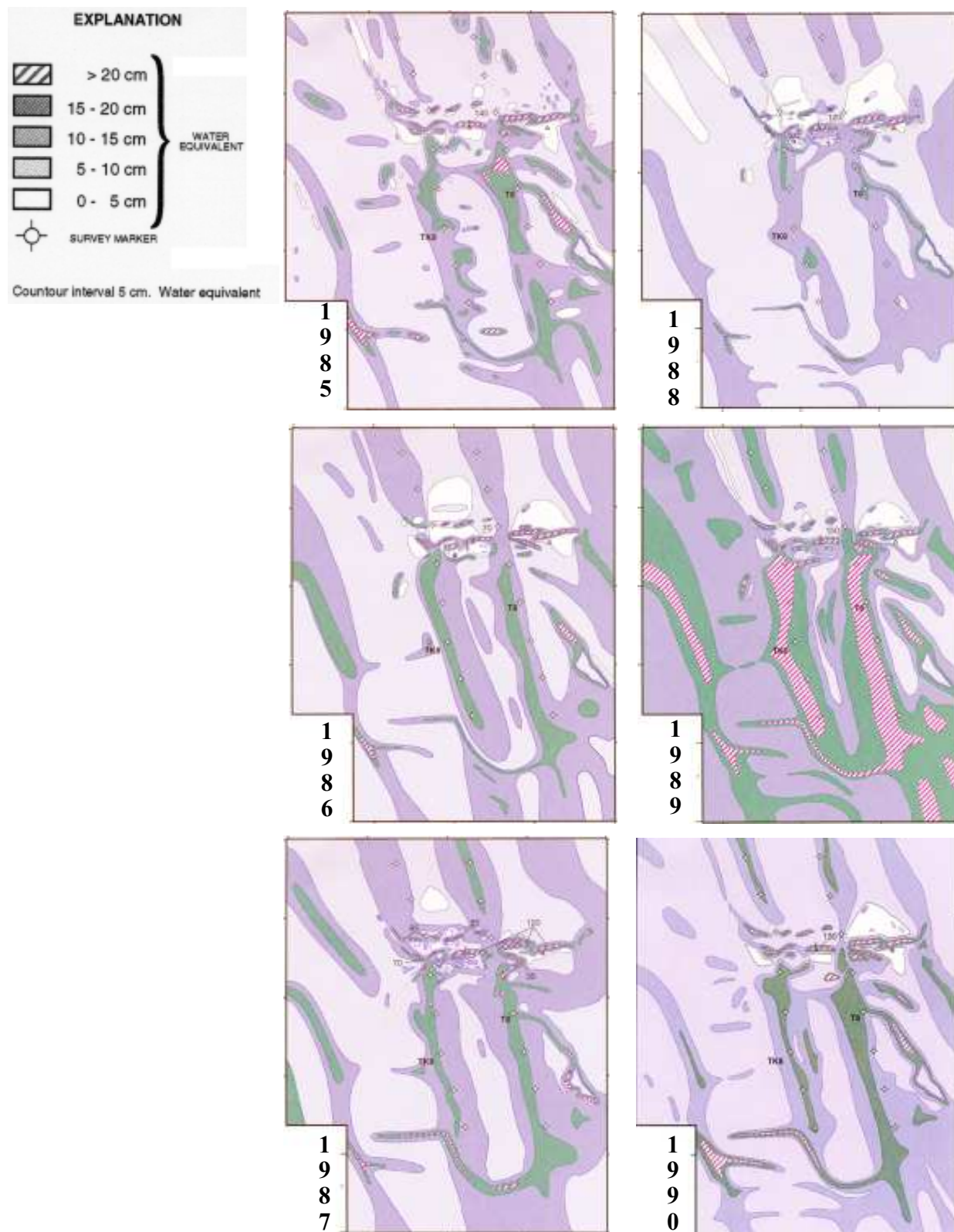
TRANSPORT DISTANCE

The transport distance was defined by Tabler (1971, 1975) as the distance which the average sized snow particle will travel before it completely disintegrates or

sublimates. By using the flux of snow caught in drift traps from the two primary winds on the Arctic slope, combined with P_r , i.e., the difference between P and P_t , the transport distance can be calculated. The values obtained from the drift traps at Atqasuk were 2.6 km for the east winds and 2.3 km for the west winds (Benson, 1982). If the values for Q_d are 15% low the transport distance would increase to about 3 km which is essentially the same as the value obtained by Tabler (1975) for Wyoming.

SNOW STRUCTURE

Measurements made on Alaska's Arctic Slope snowpack since 1961 show that tundra snow has two distinct facies. One is the thin veneer of depth hoar and wind slab that forms over most flat areas of the tundra. The second is the deeper, denser snow that forms drifts in topographic depressions and in the lee of ridges and



END OF WINTER SNOW WATER EQUIVALENT MAP ECOLOGICAL RESEARCH SITE TOOLIK LAKE AREA, ALASKA

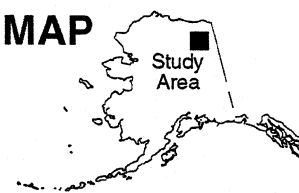
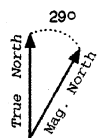


Fig. 10. Snow distributions at Imnavait Creek.

bluffs. A summary of our knowledge of these structural features is taken from Benson and Sturm (1993).

The veneer of snow that forms on the tundra resembles the top annual unit of snow on the Greenland Ice sheet. It usually consists of a basal layer of depth hoar overlain by a sequence of harder snow. Tundra snow differs markedly, however, from snow on a glacier or ice sheet in that it interacts in a complex way with the tundra vegetation producing marked "horizontal" variability in textural and thermal properties. In particular, in the autumn when the tundra is still warm enough to cause melting, basal snow layers can develop extreme heterogeneity due to the formation of icy places between tundra tussocks. Tundra snow is also subjected to much stronger temperature gradients and higher upward-directed heat fluxes than the equivalent layer of snow on a glacier or ice sheet. This leads to relatively more depth hoar in the tundra snow pack. Average depth ranges from 10 to 40 cm. Wind-slab densities can be as high as $0.54 \text{ g}\cdot\text{cm}^{-3}$ (grams per cubic centimeter) while the depth hoar density is frequently less than $0.20 \text{ g}\cdot\text{cm}^{-3}$. The overall density of the tundra snowpack is slightly less than $0.30 \text{ g}\cdot\text{cm}^{-3}$; the comparable value for drifted snow generally exceeds $0.40 \text{ g}\cdot\text{cm}^{-3}$.

The structure of snow on the tundra has been studied by excavating trenches and measuring the snow strata in them. Stratigraphic units can be correlated from the veneer on the tundra to snow in the drift traps. The chief difference is that individual wind slabs may be 10 times thicker in the drift trap. Also, due to the great thickness of drifts (sometimes in excess of 5 m), temperature gradients across drifts are considerably smaller, hence depth hoar development is reduced. Depth hoar strata found on the tundra are often absent in the drift sequence.

DEPTH HOAR

Processes of snow drifting are best studied on the Arctic Slope, while processes governing depth hoar formation are best studied in the interior (Trabant and Benson, 1972; Sturm, 1991). The extreme continental climate in the interior of Alaska, near Fairbanks, includes ideal conditions for the formation of depth-hoar in the seasonal snowpack, which is usually less than 1 m deep. The snowpack lasts for 150-200 days at temperatures well below freezing (-40°C is common) and has a large and persistent thermal gradient ($1^{\circ}\text{C}\cdot\text{cm}^{-1}$ is common) between the ground below and the air above. The resulting depth-hoar has exceptionally low density (0.19 to $0.20 \text{ g}\cdot\text{cm}^{-3}$ compared with 0.28 to

$0.30 \text{ g}\cdot\text{cm}^{-3}$ in alpine regions) and it sometimes spreads upward through the entire snowpack before the end of winter (Sturm, 1991). Significant fractionation of stable isotopes ($^{18}\text{O}/^{16}\text{O}$ and D/H) occurs during the formation of depth hoar, and the upward flux of water vapor extends to the soil below. (Friedman and others, 1991).

Much of the above research was done on snowpacks which were as free from horizontal variability as possible. We are now working to determine the extent of variability in the natural snowpack and the way it interacts with vegetation. A significant part of this is the effect of "tree wells" formed around spruce trees (Sturm, 1992).

A study of passive microwave data derived from aircraft and satellites is underway by the author and colleagues at NASA's Goddard Space Flight Center and CRREL (Hall and others, 1989; 1991). We are examining an anomalous low-temperature region immediately north of the Brooks Range. Brightness temperatures are being plotted along selected traverses extending across Alaska from the Pacific Ocean to the Arctic Ocean. One data set spans the time in 1989 when record low January temperatures were followed within five days by record February high temperatures.

The role of depth-hoar in controlling microwave brightness temperatures has attracted attention for more than a decade (Hall and others, 1986). A detailed study of the specific effect of depth-hoar on passive microwave emission was done by removing sequential layers of the snowpack in interior and arctic Alaska. A maximum reduction in the effective emissivity was achieved by a depth-hoar layer 30 cm thick; layers thicker than this did not reduce the emissivity any further (Sturm, and others, 1992).

MCCALL GLACIER AND SEASONAL SNOW

In 1957, during the IGY, the McCall Glacier in the Eastern Brooks Range (Fig. 11) was one of a set of index glaciers, chosen for detailed study. This work was partly supported by NARL. In 1969, a renewed study by the Geophysical Institute, with Gerd Wendler as Principal Investigator, was initiated with NARL support. This project continued until 1975. Measurements made in 1987, and up to the present in a new study lead by Keith Echelmeyer, have demonstrated unequivocally that the glacier is losing mass (Fig. 12). Furthermore, the rate of loss, based on precision surveying across several cross sections in-

creased by a factor of three in 1977 (Rabus, and others, 1995). The McCall Glacier has also been shown to be representative of other glaciers in the Romanzof Mountains. (Rabus and Echelmeyer, 1998) This is one of the best pieces of information that clearly shows the effect of climatic warming in the Arctic.

Foster (1989) looked at the trend of earlier snow melt in recent years, recorded at Barrow as an expression of climate change. Dutton and Endres (1991) pointed out that the urbanization around the weather station at Barrow dominated the situation so that no conclusions about climate change over this brief time could be made. Foster, Winchester and Dutton (1992) investigated satellite data from remote areas and found a tendency for earlier snow melt in the 1980's. We have measured the timing of snow melt on the tundra in the Innavaik Creek area in detail for more than a decade (Hinzman, and others, 1996) and it seems to show no apparent trend toward earlier snow melt as shown in Figure 13 which includes data up to 1999.



Fig. 11. Aerial view of McCall Glacier.

It is important to note that the integration of climate indicated in the ablation rate of the McCall glacier clearly shows a trend, which can probably be interpreted as climatically driven. The 14-year record of snowmelt on the tundra does not.

AUFEIS

Studies of *aufeis* (overflow icings on streams) on the Arctic Slope were done in connection with the McCall Glacier project and also by D.K. Hall (1980, 1981) from NARL as a base. Li and others (1997) have recently applied Synthetic Aperture Radar (SAR) to determine the growth of *aufeis* as winter progresses on the Arctic Slope. *Aufeis* on some rivers is extensive enough so that it plays the moderating role of a glacier in a drainage basin. This is true of the Sagavanirktok

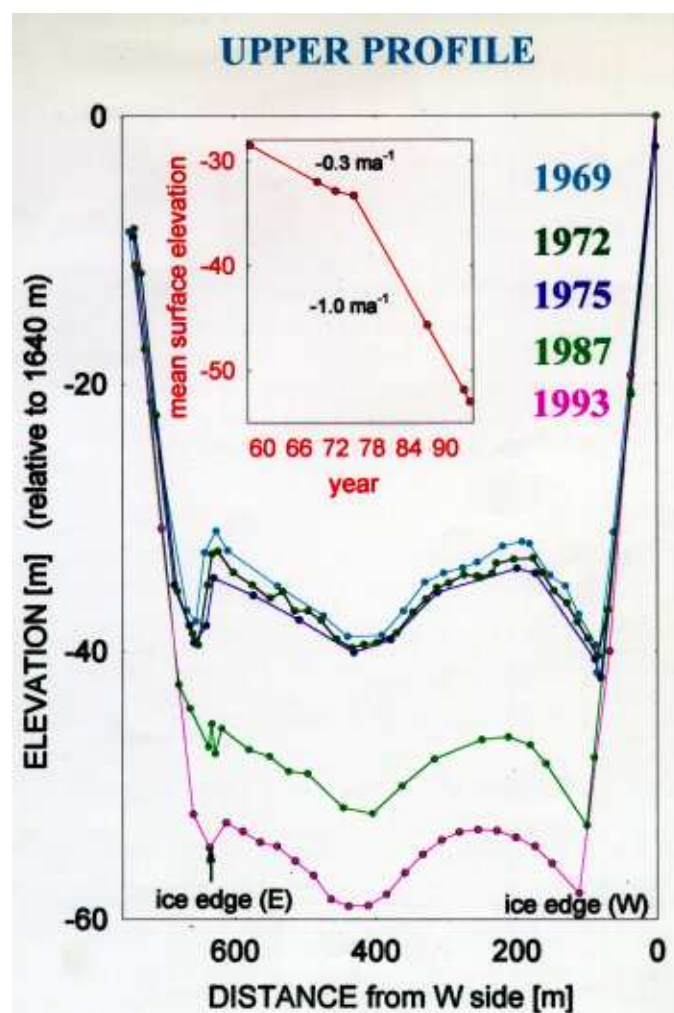


Fig. 12. Mass loss on McCall Glacier (Rabus and others, 1995).

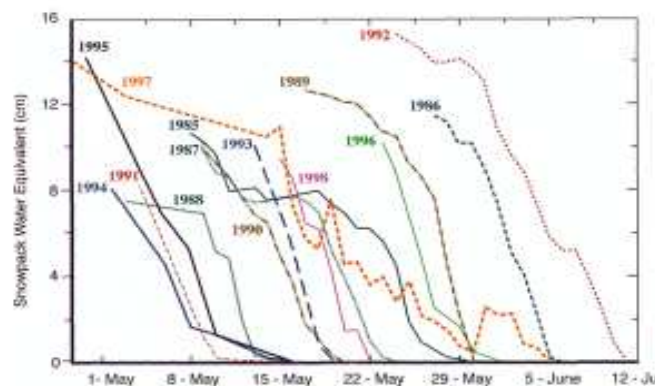


Fig. 13. Melting rates at Innavaik Creek, fourteen seasons of observation. Ablation is expressed as water equivalent of the snowpack (Hinzman and others, 1996).

River which has a markedly different hydrograph than the adjacent Kuparuk River.

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Contributions through NARL to Monitoring and Process Studies of Atmospheric Greenhouse Gases

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ABSTRACT. The issue of atmospheric warming because of a worldwide increase in carbon dioxide (CO₂) and other radiatively important trace gases may have important consequences in polar regions, especially the Arctic. Although the arctic regions are snow and ice covered most of the year, the land and sea contribute significantly to the exchange of CO₂ with the atmosphere. The first continuous observations of CO₂ in the U.S. Arctic began at the Naval Arctic Research Laboratory (NARL) in 1961 and were terminated in 1967. Monitoring of atmospheric CO₂ was carried out by infrared analysis from sites located near the NARL and from air samples collected in flasks from NARL supported ice islands and other locations on the North Slope. The NARL CO₂ monitoring site established the seasonal and secular trend for CO₂ at this location. It was also found that the bogs and ponds underlain by permafrost provided a source of CO₂ and other trace gases to the arctic atmosphere. During the spring thaw subnivean levels of CO₂ increased to more than 2000 ppm. Tundra lakes and ponds appear to be supersaturated in CO₂ with respect to air and suggest that they are a significant source of CO₂ to the arctic atmosphere during the period of melt.

Key words: arctic climate, carbon dioxide, carbon monoxide, global warming, lakes and ponds, methane, sea ice, transport of CO₂, tundra

INTRODUCTION

Science students nearly everywhere these days take for granted the concerns over global climate change and the central role that atmospheric trace gases play in those concerns. Yet few students appreciate how long it took for science to become concerned, and fewer still could articulate the importance of early atmospheric studies in the Arctic to raising awareness of the connection. A few years after the pioneering contributions made at NARL by Scholander and Irving (Elsner, this volume) to studying the composition of ice-entrapped fossil atmospheres, NARL played a key role in developing analysis of trace gases as indicators of global change.

BACKGROUND

In 1959, a little over 60 years had passed since the Swedish geochemist, Svante Arrhenius, published the idea that as human activity puts ever more carbon dioxide (CO₂) into the atmosphere, global warming is likely to take place. Although Arrhenius' suggestion had been reinforced independently by the American Thomas C. Chamberlin (Weart, 1997) scientific wisdom persistently held that there were many forces other than carbon dioxide affecting climate. A textbook quote, for example, summarizes the standard view of climate change prevailing through the 1940s:

We can say with confidence, that climate is not influenced by the activities of man except locally and transiently (Quoted without attribution by Weart, 1997).

This downplaying of human influence on climate had already been challenged in a paper by G.S. Callendar who asserted (Callendar, 1940) that since the 1890s the carbon dioxide level in the world's atmosphere had risen by about 10 per cent. Callendar further suggested that increased CO₂ levels could explain an observed atmospheric warming during the same period. Most meteorologists continued to doubt the validity of these calculations: the CO₂ data were suspect for lack of precision.

By the 1950s improvements had been made in infrared spectroscopy. Gilbert Plass at Johns Hopkins University in 1955 removed any doubt that adding carbon dioxide to the atmosphere would mean that more of the planet's outgoing infrared radiation would be intercepted by an atmosphere enriched in CO₂ (Weart, 1997). By the late 1950s there was not a growing awareness that the world's atmosphere and oceans could not serve as an infinite sink for pollutants; nor was it acceptable to regard belching smokestacks only as symbols of prosperity. Charles Keeling, at the Scripps Institution of Oceanography (SIO) set out to make CO₂ measurements with the utmost precision in the late 1950s to measure seasonal (cyclic) and secular (non-

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cyclic, or unidirectional) changes in CO_2 . He used infrared analysis, backed by careful manometric measurements and calibrated reference gases. The original plan was to establish a baseline so that after a decade or more the trend in atmospheric concentration of CO_2 could be determined with certainty. By late 1959, after two years of measurement, a secular rise had been detected (Keeling, 1960). Keeling's measurements of CO_2 were made by analyzing air collected in evacuated flasks collected from ships-of-opportunity, and at Mauna Loa, Hawaii and in Antarctica, by continuous infrared analysis. There were few data at that time for CO_2 in the Arctic.

Long-term continuous measurements of CO_2 began in 1959 through the Department of Atmospheric Sciences, University of Washington, Seattle, based out of the Naval Arctic Research Laboratory (NARL) (Kelley, 1973). This contribution by NARL owed its start to convergence of U.S. Navy-ONR support, the involvement of the Department of Atmospheric Sciences at the University of Washington in atmospheric trace gas investigations, and my own interest in Keeling's research. The Barrow research also collaborated with the Scripps Institution of Oceanography (SIO) by using the SIO system of calibrations, a system still in use today. Although atmospheric observations of CO_2 were our primary goal, the group also pursued other interests in the dynamics of this gas in arctic terrestrial and marine environments.

ESTABLISHING AN ARCTIC BASELINE

CO_2 was sampled continuously by infrared analysis at two locations chosen for their sufficient distance from sources of combustion at Barrow (Figs. 1, 2). As an added check on accuracy, intercalibration with the SIO regular flask samples of air were taken and analyzed at SIO. In order to extend the observations throughout the Arctic Basin, evacuated flask samples of air were collected from drifting ice stations on the Arctic Ocean. Continuous CO_2 observations were made from 1961-1963, and from 1965-1967. No observations were made in 1964 because the station was one of the casualties of the severe storm of October 1963 (Editor's Introduction, this volume: Fig. 1), which destroyed the field laboratory and its instrumentation. After the ravages of the storm were assessed it was decided to find a new "high ground" clean air location to replace the beach location. A site near North Meadow Lake, about 2 km south of the NARL on an ancient beach ridge was established to continue the observations from 1965 to 1967. In 1966 and 1967 the National



Fig. 1. The first CO_2 monitoring station at NARL as it appeared in 1961. The building and site on the beach at the end of the airstrip were designed to take advantage of prevailing winds. Air was pumped from several levels on a 16-m mast (foreground), which also bore meteorological instruments for micrometeorological studies.



Fig. 2. Interior of the monitoring station shown in Fig. 1. Author is adjusting controls on the first nondispersive infrared CO_2 analyzer fabricated by Analytical Systems of Pasadena CA for installation at NARL. Photo, Alaska Photo, 1961.

Atmospheric and Oceanic Administration (NOAA) became interested in monitoring atmospheric trace gases and other geophysical variables. Barrow was one of the candidate sites for a station in the NOAA network of Global Monitoring for Climate Change (GMCC, known today as Climate Monitoring and Data Logging, CMDL; see Townshend, this volume: Fig. 1). Routine observations of CO_2 ceased to be a NARL function in 1967, but were taken over by NOAA in 1972. Investigators of the original group decided to concentrate further research on process-

oriented studies in the terrestrial and marine environments.

INTERPRETING ARCTIC RESULTS

This juncture, between how NARL helped establish an arctic atmospheric “baseline” by 1967, and the later pursuit of “process” research makes a good place to review what we have learned. Annual and seasonal variation in atmospheric CO₂ at Barrow from 1961 to 1967 had been characterized (Fig. 3). A seasonal oscillation is clearly evident, attributable primarily to seasonal CO₂ uptake in summer by land plants in the Northern Hemisphere’s disproportionately large land mass. The winter-to-summer amplitude (approximately 12 ppm mixing ratio or 12×10^{-6} atmospheres partial pressure) is greater in the Arctic than at Mauna Loa, Hawaii (6.5 ppm) or Antarctica (0.5 ppm). Short-term excursions superimposed on seasonal trends suggest a

response of CO₂ to regional and local weather patterns. Similar observations were made for ozone (O₃), which was monitored concurrently. Figure 4 compares the seasonal CO₂ trend at Barrow with that of drifting ice station ARLIS-II. The Barrow CO₂ signal is evident deep into the Arctic Basin, far removed from terrestrial sources and sinks. Figure 5 shows the long-term trend of atmospheric CO₂ in the Barrow area. There was a secular increase of about 0.8 ppm per year during the monitoring period.

PROCESS STUDIES AFTER 1967

The wet tundra of the coastal regions of arctic Alaska consists of an active thaw layer of about 0.6m (2 feet) underlain by about 600 m (1900 feet) of permanently frozen ground (permafrost). Because of the presence of permafrost, the tundra soils, shallow lakes, and ponds experience bi-directional freezing—that is, from

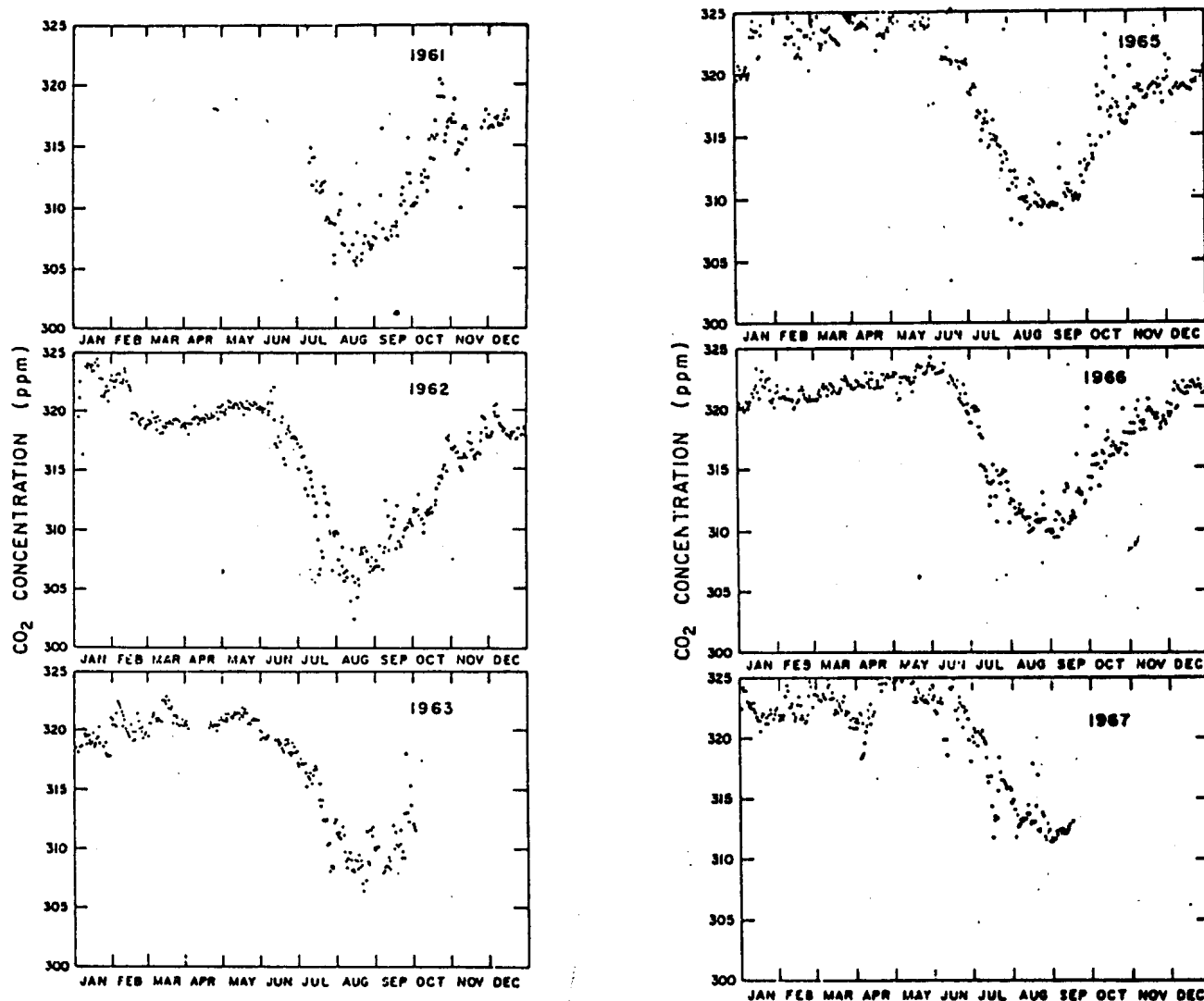


Fig. 3. Daily mean CO₂ concentrations in ppm, 1961-1963; 1965-67, taken from Kelley (1973). These are the early data that now appear in NOAA-CMDL graphics that illustrate seasonal (cyclic) variation and long-term secular changes in trace gases at high latitudes.

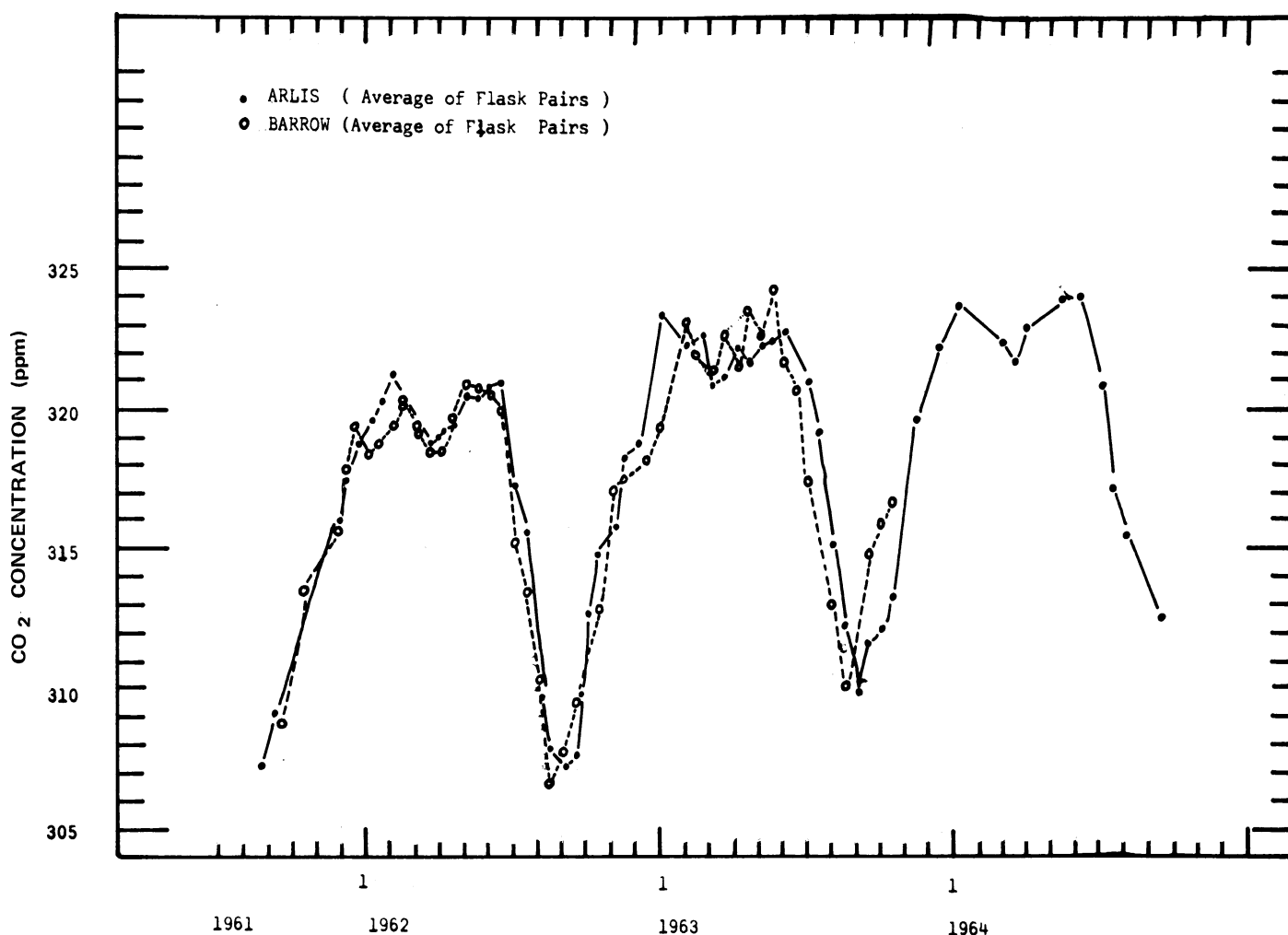


Fig. 4. Atmospheric carbon dioxide comparisons between Barrow, and drifting ice island station, ARLIS II, confirming that even far from land, seasonal cycles and secular trends in CO_2 are detectable, and that local terrestrial sources do not corrupt the samples. From Kelley (1973).

the surface downward, and from the bottom of the active layer upward—in the fall (Kelley and Weaver, 1969; Stearns, 1966). Depending on the soil type, 500 to 90 000 litres of CO_2 per hectare could be released to the atmosphere during the autumn freeze-up (Coyne and Kelley, 1971). A springtime phenomenon is the sudden release of CO_2 under the snow. Subnivean CO_2 levels are generally higher than ambient air throughout the year, but the sudden release in spring may exceed 2000 ppm over ambient (Kelley, et al., 1968).

The diurnal and seasonal fluctuations in the partial pressure of carbon dioxide (PCO_2) with respect to air were measured in lakes and ponds in the early 1970s. The calculated transfer rate to the atmosphere from the lakes (Fig. 6) was $0.56 \text{ g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$ (grams per square metre per day) and that for shallow ponds was $1.95 \text{ g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}$. The high levels of CO_2 supersaturation in the surface water of the ponds and lakes on the arctic coastal plain of Alaska and their physical extent (50 to 80 per cent of land surface) suggest that they are a

significant source of CO_2 entering the atmosphere (Coyne and Kelley, 1974)

Arctic tundra soils may also be a significant source of carbon monoxide (CO) during the period of spring thaw, but the output of this gas lags a few weeks behind the peak in CO_2 evolution described earlier. Atmospheric CO in the Alaskan arctic atmosphere is about 0.05 ppm by volume or less. Carbon monoxide concentrations in bubbles escaping from tundra lake ice are on the order of 100 ppm, and those from rotting sea ice, 5–20 ppm (Gosink and Kelley, 1979). During the later part of spring thaw, CO at the base of tundra plants was consistently observed to be about 20–40 ppm. Methane (CH_4) also shows enrichment in arctic lakes and soils (Kelley and Gosink, 1988).

Trace gases CO, CO_2 , and CH_4 appear to escape the tundra to the atmosphere year round. The periods of re-freezing of the tundra in the fall, and thaw in the spring are important for the increase in concentration

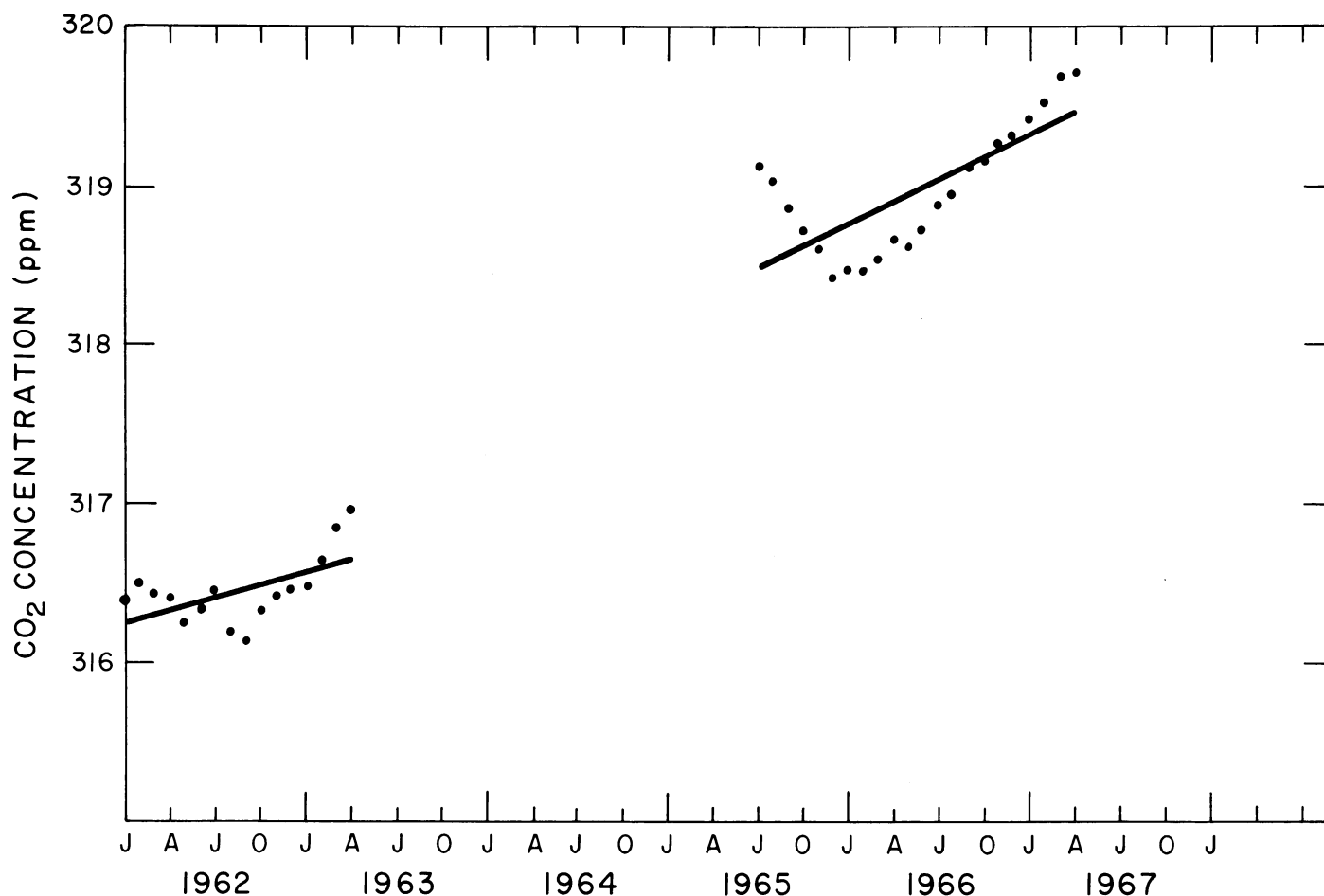


Fig. 5. Twelve-month running mean and secular change in atmospheric CO_2 levels from Barrow's stations (Kelley, 1973).

of trace gases, particularly CO_2 , evolved to the atmosphere. Keeling et al. (1996) analyzed the long-term trend in the CO_2 seasonal amplitude. They reported that the annual amplitude of the seasonal cycle has increased by 20 per cent in Hawaii and 40 per cent in the Arctic, since the 1960s. They suggested that the increased amplitude reflects increasing assimilation of CO_2 by land plants in response to climate changes accompanying recent rapid increases in temperature (Keeling et al., 1996). Chapin et al. (1996) also suggested that increased plant respiration during winter, a factor not considered by Keeling et al. (1996), could increase the amplitude of atmospheric CO_2 independently of any change in summer net primary production.

Recently much emphasis has been placed on global climate change and the role of the radiatively important "greenhouse" gases in causing a warming trend. The effect is likely to be significant in the Arctic resulting in a thinning of the sea ice cover and more rapid melting of glaciers. The complexity of interactions between

sea-land-ice and atmosphere and the lack of precision that currently is associated with information on the various processes in the arctic regions makes climate related predictions subject to errors. For example, rapid melting of arctic sea ice and glaciers may produce abundant fresh water, which may alter ocean currents and bring about a cooling rather than a warming effect. There are numerous effects possible on the polar environment that may occur as a consequence of an increase in "greenhouse" gases. There are also numerous compensating factors in nature. Any rapid and persistent changes brought about by mankind, however, may prove to be overwhelming in the short-term.

It is gratifying that the continuity of observations begun at NARL some 40 years ago is maintained today by NOAA-CMDL, and that Barrow and other North Slope communities continue to play a significant role in supporting analyses of atmospheric composition and global change, through projects such as SHEBA and ARM (Zak et al., this volume).

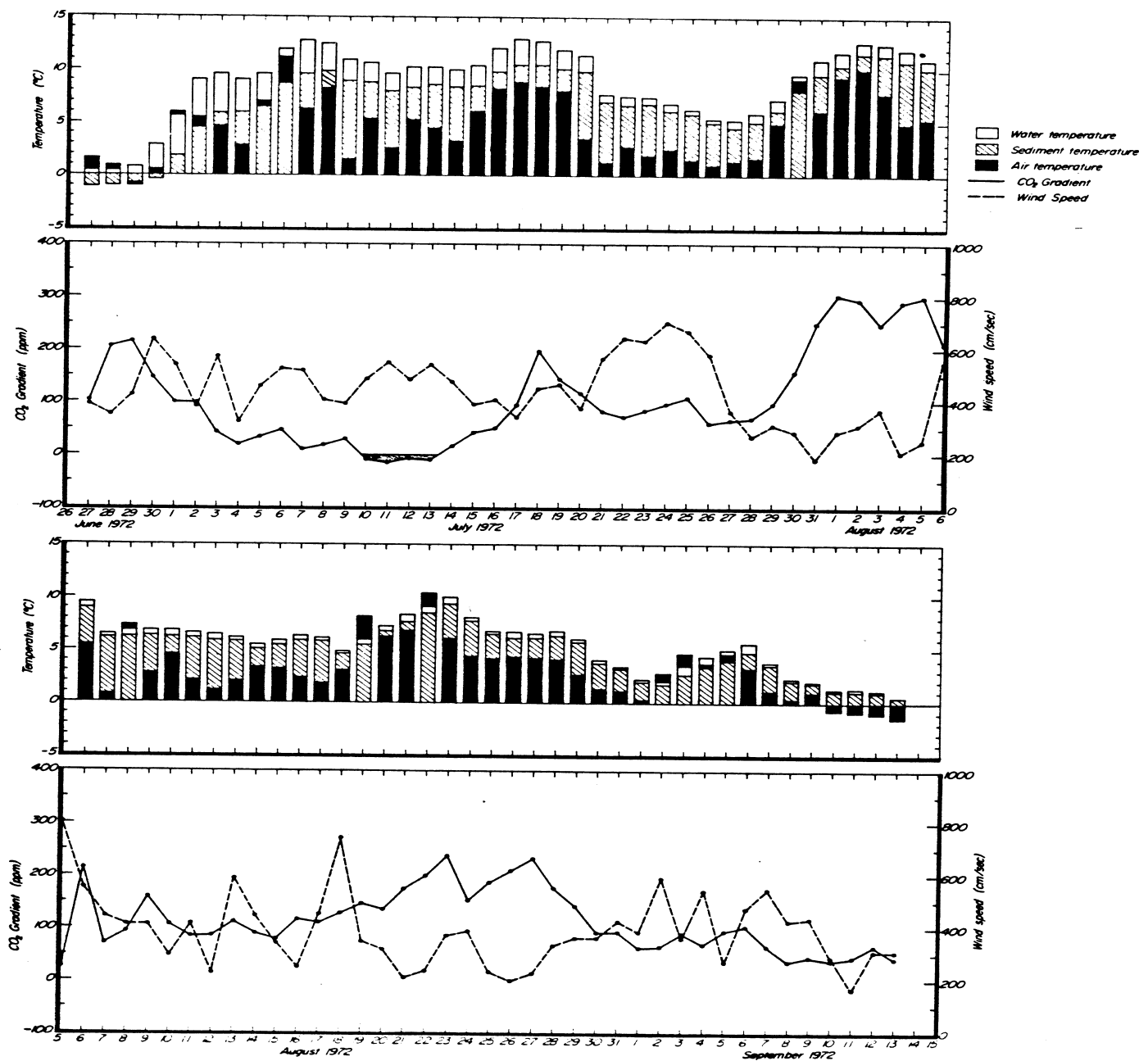


Fig. 6. Mean daily temperatures (air-water-sediment), wind speed, and CO₂ gradient (PCO₂-pCO₂). CO₂ gradients are less for a large tundra lake than for a shallow pond. The lake shows a brief period of undersaturation in CO₂ with respect to air, possibly the result of phytoplankton blooms (Coyne and Kelley, 1974).

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Aurora Research During The Early Space Age

Syun-Ichi Akasofu¹

ABSTRACT: The progress of a ground-based study of auroral morphology and of geomagnetic disturbances in the 1960s is described as a personal account. It is emphasized that although many conclusions are stated simply in a few sentences in modern monographs, there was a decade of history behind reaching those conclusions against pre-existing dogmas. Some of those conclusions are results of a naive question by a graduate student, which have opened a new discipline. Although the field of space physics is now becoming quantitative, the trend does not necessarily mean that the field is coming to an end: often, when the ability of researchers is limited by pre-existing dogma, the field may appear to become mature. Thus, it is important to encourage young researchers to develop the field in the ways they believe in, rather than emphasizing only quantitative features in future research trends. It is also emphasized that as a result of several recent advances in ground-based research, a new advance can be made by integrating ground-based and satellite-based research, together with theoretical and modeling effort, combined.

Key Words: aurora studies, International Geophysical Year (IGY), auroral substorms, auroral oval, geomagnetism, geomagnetic stations, satellite imagery, simultaneous observations, all-sky cameras

INTRODUCTION

The development of auroral science during the 1960s may provide a hint in advancing magnetospheric physics during the first few decades in the 21st century. It is pointed out that there are always periods when many scientists in a particular field tend to feel that there is nothing left to be done. Such is the time when a particular dogma or paradigm matures and prevails, although there might exist many fundamental unsolved problems which are tacitly believed to be understood or solved. A new era in such a field could be opened as a result of a naive question or challenge to those problems by a newly arriving graduate student. This article begins with a personal account of the progress of auroral morphology in the 1960s. Although satellite-based space research has been more emphasized in magnetospheric physics for many years, ground-based space physics has recently reached a very interesting stage in contributing to space physics on an equal basis with satellite-based space physics.

FROM AURORAL ZONE TO AURORAL OVAL

It was Loomis (1860) who collected extensive records of auroral appearance, and found that the aurora tends to appear as a fairly narrow belt centered around a point at the northwestern tip of Greenland, not at the geographic pole. Fritz (1873), using more data covering the period from 503 B.C. to A.D. 1872, confirmed Loomis' findings and constructed his well known map of *isochasms*, the lines of equal average annual fre-

quency of auroral visibility expressed by number of nights per year. The maximum frequency of auroral visibility was found to lie approximately along Loomis' belt. This auroral belt has been called the *auroral zone*.

The center line of the auroral zone, the narrow belt of high auroral visibility, coincides fairly well with the geomagnetic latitude (gm lat.) of 67°. In Alaska, this coincides approximately with the latitude of Fort Yukon. The width of the auroral zone is about 5 - 6° in latitude. Thus, on a polar map centered around the geomagnetic pole, the auroral zone is a circumpolar belt.

Since then, it had tacitly been believed for more than 100 years that the auroral zone was the actual belt along which auroral arcs lie. It was Sydney Chapman, the President of the International Geophysical Year (IGY), and Christian Elvey, the Director of the Geophysical Institute, University of Alaska, who thought that the actual belt of the aurora should be determined photographically, not by statistics as done by Loomis, Fritz, and others. For this purpose, they took the leadership in constructing all-sky cameras.

I should note that the IGY coincided with a sort of "golden age" for auroral spectroscopy. All-sky cameras were not considered to be a scientific instrument, compared with sophisticated spectroscopic instruments. In fact, some of my senior colleagues advised me by saying that the aurora should be the same in Alaska, Siberia, Canada, Norway; that physics of the aurora should be the same everywhere; that the distribution of

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the aurora was not a major issue, and thus that I would be wasting time to work on the distribution of the aurora. I recall objecting to such an argument by saying that the fact that auroral arcs appear in a very specific belt called the auroral oval, not all over the polar region, telling us something about their origin, so that it was important to determine the distribution accurately.

Auroral researchers in several countries responded to Chapman and Elvey by designing and constructing their own all-sky cameras. During the IGY, such cameras were operated at more than 100 locations and took photographs of the sky at one-minute intervals regardless of sky conditions. The films were then sent to the World Data Center in Moscow and the Geophysical Institute, University of Alaska.

I became a graduate student of the Geophysical Institute, University of Alaska, in December 1958 and had an opportunity to observe the aurora with my colleague students. I observed that the aurora tends to appear in the northern sky in the evening, advance toward the zenith (or even to the southern sky) of Fairbanks (gm lat. 64.6°) and recede toward the northern sky in the morning. Actually, this was a well-known fact at that time. I recall that I asked Elvey why this shift occurs, if auroral arcs were supposed to lie along the auroral zone. His response was that it was perhaps because auroral arcs always form at the centerline of the auroral zone (gm lat. 67°), then after their formation, the arcs move toward the Equator.

My question was simply that if the concept of auroral zone was correct, we should be able to see auroral arcs near the zenith of Fairbanks at 6 pm local time, when the sky is dark enough around the winter solstice. Instead, auroral arcs always appear near the northern horizon first and advance toward the Equator. My question to Elvey was that of a naive graduate student at that time.

After this conversation with Elvey, I examined all-sky films taken at Fort Yukon, Alaska (gm lat. 66.6°) which is located at about the center line of the auroral zone. I was greatly surprised to find that auroral arcs behave in a similar way as in Fairbanks. That is, auroral arcs appeared first near the northern horizon. Next, I examined all-sky films from Barrow (gm lat. 68.5°), well north of the centerline of the auroral zone. It was even more surprising to me that auroral arcs behave in a similar way. The only difference is that the local time of the first appearance and their arrival at the zenith is earlier at Fort Yukon than in Fairbanks, and even earlier at Barrow.

All-sky films from many arctic stations started to arrive at the Geophysical Institute in 1959 and 1960. It was my finding that the actual distribution of auroral arcs agrees with the auroral zone only during midnight hours and deviates greatly at the other local times. At that time, however, I could not determine the distribution on the dayside because of the lack of data.

It was Feldstein (1963) who determined completely the distribution of the aurora at all local times, using the films from Heiss Island and others, which can observe midday auroras. His distribution showed that the belt of the auroral zone is located at about 78° during midday hours, instead of 67° . Further, the center of the belt is shifted by about 3° from the geomagnetic pole toward the midnight sector. This belt is called the *auroral oval*. Since the results obtained by Feldstein are basically the same as mine in dark hours, I supported his results immediately.

Feldstein's results got little attention from the scientific community. Worse, since the auroral zone had been believed to be the belt of auroral arcs for more than 100 years, it was difficult for us to convince our colleagues of the validity and significance of the auroral oval.

In order to convince the scientific community of the validity of the concept of the auroral oval, I planned several projects. The first one was to establish the Alaska meridian of all-sky cameras. Taking advantage of the earth's rotation, the meridian chain of all-sky cameras can scan the entire polar sky (like an azimuth-scanning radar at an airport) once a day, and can delineate the auroral oval which is fixed with respect to the sun. I believe that this is the 'largest scanning device on earth'.

The second project was to fly along auroral arcs, since the flight path should be able to delineate the auroral oval. Both a US Air Force jet from Hanscom Air Force Base and a NASA jet from Ames Research Center participated in the operation. The flight paths clearly delineated the auroral oval. George Gasmann, Jurgen Buchau and his colleagues of the Phillips Laboratory were instrumental in accomplishing this task. It seemed, however, that the scientific community in general was not much interested in such observational results at that time.

We had to wait for the full recognition of the auroral oval until 1971 when a scanning instrument, devised by Cliff Anger, aboard the ISIS-2 satellite, imaged the

entire oval (Lui et al., 1975). After this event, the concept of the auroral oval was accepted as if nothing had happened earlier.

In any modern monograph on the aurora, one can find a simple statement that auroral arcs lie along the auroral oval. It is interesting to recognize that such a simple fact had a long history, about a decade of struggle for acceptance by the scientific community. Personally, it started out with a naive question about the well-known daily auroral behavior at that time. Recalling those days, I appreciate the foresight and courage of both Chapman and Elvey for taking the leadership of the all-sky camera project, in spite of the fact that auroral spectroscopists and auroral physicists in general paid little attention to it. Also, as far as I know, an all-sky camera was used for the aurora by Gartlein for the first time.

FROM FIXED PATTERN TO AURORAL SUBSTORMS

It had long been believed on the basis of study of the aurora by Fuller (1935) and Heppner (1954) that in the evening sky, auroral arcs always had a quiet and homogeneous form, that auroral arcs were always very active in midnight hours and became patchy in the morning sky. In this view, auroral activities are fixed with respect to the sun so that the earth and a single observer at a point on it rotates under such a pattern of auroral activity once a day. That is, quiet forms, active forms, and patchy forms are familiar features in the evening, midnight and morning skies, respectively.

At the beginning of the IGY, little was known about how auroras behave *simultaneously* in Siberia (in local evening hours) and Canada (in local morning hours) when auroras became suddenly active over the Alaskan sky (in local midnight hours). There had not been any simultaneous observations of auroras over a long local time span until that time.

All-sky films from even a single station gave me a picture quite different from the statistical concept mentioned above, since auroral arcs can be quiet during midnight hours. Further, all-sky films during a single night showed that auroral arcs can transform themselves from quiet to active, and back to a quiet form, twice or three times during a single night. This fact suggested to me either that the fixed pattern concept was not correct or that the earth rotated twice or three times on those nights!

As a graduate student, I was obviously puzzled, but

overwhelmed by the firm believers in the fixed pattern. I decided to examine *simultaneous* all-sky photographs from Siberia, Alaska and Canada, when Alaska was in the midnight sector. I found that when an auroral arc is quiet in the Alaskan sky, it is also quiet over Siberia and Canada. When an auroral arc suddenly brightens and moves rapidly poleward over the Alaskan sky, this activity generates a large wavy or folding structure (the westward traveling surge), which propagates along the arc toward Siberia (toward the evening sky). This surge-like activity was recorded first at the Siberian station closest to Alaska several minutes after its formation over Alaska and subsequently at other earlier evening stations. This activity could propagate all the way to the dayside of the oval with a speed of a few kilometres per second. At the same time, auroras over Canada became active, often forming an inverted Ω -shaped form (called the omega band). To the south of the omega band, auroral arcs became folded in a very complicated way. Folded portions appear as shafts of lights or patchy forms, scattering all over the sky.

More importantly, when auroras over Alaska become quiet again, in about two to three hours, auroras over Siberia and Canada also become quiet. Further, such an activity is often repeated twice or three times a night. Chapman coined the term 'auroral substorm' for this transient phenomenon (Akasofu, 1964). There was little mention of such auroral features in the then newest and most authoritative book published by Chamberlain (1961). Therefore, I sent a paper to the *Journal of Geophysical Research*, reporting on the above findings. The paper was rejected, on the basis that there was nothing worth reporting. So I decided to analyze simultaneous all-sky films from a large number of stations and became more convinced of the validity of my findings. A new paper was sent to the late Sir David Bates, then the editor of *Planetary and Space Science*, who accepted it immediately by himself. I could assume this because I received his acceptance letter only about 10 days after sending the paper to him.

Nevertheless, I found it very difficult to convince my colleagues of my findings. This was particularly the case for those who were experienced in observing the aurora. This was because a single observer standing at a point on the earth is carried by the earth's rotation with a speed of 15° in longitude per hour, so that he gets an impression *statistically* that the fixed pattern was correct. Elvey firmly believed in the fixed pattern concept. Many auroral scientists who have little experience in observing the aurora simply followed the experienced ones. Thus, it was hard to convince

anyone about the validity of the concept of the auroral substorm. The only exception at that time was Feldstein who strongly supported my findings.

Therefore, I had to devise a scheme to prove the validity of the concept of the auroral substorm. The best way is to observe the aurora from a fixed point (with respect to the sun) well above the north polar region for many hours, as the Dynamic Explorer (DE) satellite did in the 1980s. In the middle of the 1960s, this was nothing but a dream. One method I conceived was to fly westward by a jet plane. Along the latitude circle of 65° , (Fairbanks' latitude) the subsonic speed of a jet plane approaches that of the earth's rotation. Thus, a jet plane can stay in the midnight sector for about six hours by flying from the East coast at midnight to Alaska. Both NASA and Air Force jet planes contributed to these so-called 'constant local time' (midnight) flights.

On my way back to Hanscom Air Force Base from one such trip, I learned that Elvey who had already retired by then in Tucson, Arizona, was critically ill, and decided to visit him. Elvey was waiting for my results. We sat together with him at his bedside to scan the all-sky film obtained by one of the constant local time (midnight) flights, which clearly registered intermittent auroral activities in the midnight sector. We firmly shook hands. He said, "Syun, you did a good job". I believe that I had finally convinced him of the validity of the concept of the auroral substorm. I noticed that his arms were just skin and bones. I was told of his death about ten days later.

During the next decade, it was fortunate that many people realized that they can understand and interpret their observational results better in terms of the concept of the auroral substorm, rather than of the fixed pattern, but I had to wait for the results of the Dynamic Explorer satellite. Indeed, those satellite observations were the final test of the concept of the auroral substorm (Frank and Craven, 1988). After all, the patterns in an auroral substorm seen from below and above must be the same. Nevertheless, it is important to learn that it takes a much longer time than one thinks to convince one's colleagues if one's finding is radically different from what they have believed for years.

CONCLUDING REMARKS

In recent years, it has often been stated that the discipline of magnetospheric physics has matured after its extensive exploration days and that only quantitative aspects of research remain to be conducted in magnetospheric physics. It is certainly satisfying that

our discipline has recently become more quantitative than in the past. Indeed, the progress in this discipline has been remarkable.

It is a narrow view, however, to consider that only quantitative aspects of research are left to be conducted in magnetospheric physics. Those who make such a statement indicate that their own ability to advance a field saturated by dogma has reached a limit; not that the field itself is limited. A particular discipline of science may develop unexpectedly after some triggering events. Around 1955 many people voiced the opinion that the discipline of geomagnetism had matured, and that its quantitative research, such as the dynamo theory of the geomagnetic daily variations, had been completed. In that belief, they argued that geomagnetic observatories were no longer needed. Chapman strongly opposed such a view by encouraging the establishment of a close network of magnetic observatories during the IGY. I recall clearly that when I showed him that the westward electrojet extends into the evening sector (requiring a major revision of the SD current system), Chapman told me how lucky my generation was, to be able to deal with such a great wealth of IGY data. Magnetospheric physics began to grow rapidly after the advent of satellites in 1958, and since then geomagnetism has been an important element of the field. The situation was similar in the early 1960s, when many believed that nothing important was left to learn about the aurora after the publication of an authoritative and comprehensive treatise such as that by Chamberlain (1961).

These two stories illustrating development of the concepts of the auroral oval and the auroral substorm should remind us of countless parallel stories in other disciplines of science. The lesson we can learn from these stories is that the future of auroral and substorm studies is indeed wide-open so long as we, young and old, are open-minded. It is particularly important to encourage creative young researchers to develop a field in ways they believe in, rather than emphasizing only quantitative aspects of future research. It is also important to recognize that each new development is by definition qualitative. On the other hand, young researchers should be reminded that it is extremely difficult in many ways to nurture a new idea to the point that it establishes itself as an independent discipline against an established field of dogma and paradigm.

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NARL and Research on Sea Ice and Lake Ice

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ABSTRACT: After a brief discussion of the pre-1945 research programs on arctic sea ice and lake ice, the numerous contributions to this research area that have been supported by NARL are described. Also included is a bibliography that should aid readers wishing to access technical literature.

Key words: Sea ice, lake ice, geophysics, engineering.

INTRODUCTION

This account first provides an overview of a few high points of sea ice studies prior to World War II as background. It then discusses some of the varied studies that have been carried out since that time concerning the properties and behavior of sea and lake ice in the western Arctic and that have also benefited from the presence of NARL. No attempt is made to describe the details of the support that NARL provided to these projects other than to note that it varied considerably from project to project and commonly entailed the provision of room and board and laboratory space, sometimes for extended periods. During the years when NARL was operated by the United States Navy, support could also include aircraft and general logistic support. This higher level of support was invariably provided to projects operating offshore in the pack ice. Members of the Barrow community were involved in various important supporting roles.

The actual field sites involved were also highly varied. A number of projects have worked in the near vicinity of the Laboratory utilizing ice from the Chukchi nearshore, from Elson Lagoon, and from the numerous tundra lakes located to the south. Ice projects from the Outer Continental Shelf Environmental Program (OCSEAP) ranged along the coast including sites as far removed from NARL as Kotzebue Sound to the west, and Camden Bay to the east. Still other programs have operated far offshore in the Arctic Basin starting with Ice Station Alpha and Ice Island T-3 and continuing with Station Charlie, the Arctic Research Laboratory Ice Station (ARLIS) sites, and the Arctic Ice Dynamics Joint Experiment (AIDJEX). The following is a sampling of the results of these activities. The interested

reader can unearth additional related studies by referring to the bibliographic citations in the limited number of papers that are cited here.

SOME SEA ICE HISTORY PRIOR TO WORLD WAR II

The earliest descriptions of sea ice date from ~350 BC when the traveler Pythias of Massilia sailed through the Gates of Hercules (Strait of Gibraltar) and headed north, ultimately reaching "Thule," where he saw sea ice which he described as a viscid, lung-like material. Although the exact location of Pythias' Thule remains a mystery, Norwegian fjords (Nansen, 1911) and the Skagerak (Zukriegel, 1935) are two possibilities. As the centuries passed, and as exploration continued, a reasonably detailed picture of the seasonal distribution of sea ice was gradually pieced together. The goal here was to aid seafarers in avoiding this material. Some of these early publications give detailed descriptions of the ice itself based on observations made during whaling operations in the eastern Arctic (Scoresby, 1818; 1920) and along the Northeast Passage (von Wrangell, 1840). This latter individual also had the distinction of serving as the second governor of Russian Alaska. Other noteworthy early studies include 1) the work of Weyprecht in 1871-74 (1872, 1875, 1879) that led to the First International Polar Year in 1882-1883 and to the development of the basic equation that describes ice growth (Stefan, 1891); and 2) the paper by Hertz (1884) who, after pondering whether it was safe to cross a recently frozen river to see a friend, developed the basic equation that is still applied to short-term loading problems concerning both sea and lake ice as well as train tracks and pavements.

The 19th century closed with a seminal event concerning sea ice and arctic science: the voyage of the *Fram* during 1893-1896. This ice-strengthened

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ship was built by Nansen to test his theory that there was a general circulation in the pack of the Arctic Basin. Nansen reasoned that if the *Fram* were inserted into the pack at the right place, the ship would gradually drift across the Basin and ultimately exit the ice somewhere to the south of Fram Strait (named for the ship) via the East Greenland Drift Stream. This idea was based on Nansen's observation that relics from the *Jeannette*, which had sunk in 1881 to the north of the New Siberian Islands, were discovered in southwest Greenland in 1884 after drifting across the Arctic Ocean. Nansen's (1900a; 1900b) accounts of the four-year cruise of the *Fram* is one of the great polar adventure stories. When it became apparent that the drift of the *Fram* would not reach 90° N, Nansen and Johansen left the vessel in an attempt to reach the Pole by dogsled, a trip rivaled only by Shackleton's *Endurance* cruise in the Weddell Sea off Antarctica.

The scientific data collected during the drift of the *Fram* vindicated Nansen's view of the general circulation of the ice, proved that the Arctic Ocean contained several deep sub-basins, served as the basis for a simple ice drift model that still proves useful today (Thorndike and Colony, 1982), and demonstrated the importance of the Coriolis force in treating the wind drift of the ice (Nansen, 1900a; 1900b). Nansen's data also stimulated the development of the Ekman spiral analysis that is so important in boundary layer theory as applied in both oceanography and meteorology (Ekman, 1905). With the cruise of the *Fram*, sea ice ceased to be an odd afterthought in books of polar exploration, and became part of the world of modern geophysics. Somewhat surprisingly, however, the *Fram* expedition did not include studies of the properties and structure of the ice itself. This void was filled by Finn Malmgren (1927) who studied ice growth and ice properties during the drift of the *Maud* between 1918 and 1925. The quality and focus of his work cause me to consider Malmgren to be the first true student of the properties of sea ice. Unfortunately Malmgren met a tragic death on the Nobile expedition in 1928 while attempting to reach Svalbard after the crash of the airship *Italia*.

At roughly the same time as the *Fram* drift, sea ice was also entering the world of engineering. The desirability of developing an operational sea route along the northern coast of Russia had led to the construction of the first polar icebreaker, the *Yermak*, in 1898. An individual extremely influential in this project was Admiral S. O. Makarov who intended to use the ship for both research and route development. In the summer of 1901, Makarov (1901) carried out

sea ice studies using the *Yermak* for the purpose of improving icebreaker design. Makarov's project appears to be the first sea ice program that was oriented specifically to engineering implications of ice, and not justified as a trip of exploration. Eventually, this need for improved information relating to ice conditions and properties along the Northeast Passage led to the establishment in St. Petersburg in 1920 of the Arctic Research Institute whose name was later changed to the Arctic and Antarctic Research Institute (AARI).

In 1937, the first of the Russian series of North Pole (NP) stations, NP-1, was established under the leadership of Dr. Otto Schmidt and Ivan Papanin (Fig. 1). This station proved that research stations could be established on the drifting pack ice, resupplied by aircraft, and operated successfully for periods of months or even years. Its success was a testament both to the Russian understanding of sea ice conditions in the Polar Basin and to their confidence in their operational capabilities. Although major Arctic Basin activities such as the NP program were suspended for the duration of World War II, the USSR maintained limited sea ice studies during this difficult period. One of these efforts is of particular importance. In 1943, N. N. Zubov (1945) completed his book entitled *Arctic Ice*. This work served to close an era in which sea ice studies were primarily focused on its role in limiting marine transportation, by providing an innovative synthesis of widely scattered studies from both the Russian and the Western literature.

AFTER WORLD WAR II

With the start of the Cold War the focus on sea ice changed to its role in affecting operations related to national defense. For instance, the Soviets' AARI started in 1948 and 1949 to experiment with highly mobile research stations that could be deployed by



Fig. 1. Establishment of Soviet floating ice station NP-1 in early May 1937.

aircraft, building on earlier experience gained in 1937 and 1941. NP-2 was established during April 1950, and operated until April 1951. NP-3 and NP-4 followed in 1954. From 1954 on, Soviet stations maintained an essentially continuous Russian presence on sea ice in the Arctic Basin until the early 1990s.

In postwar years, the US and Canada were developing parallel interests in the same general region. This interest was clearly shown by the establishment of NARL at Barrow by the Navy in 1946-47 and also by the establishment of the Frost Effects Laboratory (FEL) in 1944 and the Snow, Ice and Permafrost Research Establishment (SIPRE) in 1949 by the Army Corps of Engineers. In 1961, FEL and SIPRE were merged to form the Cold Regions Research and Engineering Laboratory (CRREL) which to this day is the largest United States laboratory focused on problems associated with the polar regions and winter climate. The significant level of Russian activity in the Arctic Basin in the early 1950s remained unknown to western planners until mid-1954. An excellent review by Fletcher (1968) of both US and Russian activities in the marine Arctic during this time period provides maps showing the large number of temporary hydrometeorological stations established by the Russians during this period when US and Canadian knowledge of the general area was close to zero (Fig. 2). The disparity in both regional knowledge and in operational ability was clearly important in influencing the US decision to expand research activities in the Arctic, as well as in the Canadians' decision to establish their Polar Continental Shelf Project.

The first major US program in the field of sea ice physics, however, was not sited in the vicinity of NARL in the western Arctic Ocean. Instead, studies were initiated in the eastern Arctic along the Labrador Coast (1955-56) and later at Thule Air Force Base, Greenland (1956-62). The goal of these projects was to build a solid theoretical and observational foundation for moving heavy equipment over, and landing large airplanes on, sea ice surfaces under marginal conditions (Weeks, 1959). In addition to large numbers of tests on the mechanical properties of sea ice, these studies produced the sea ice phase diagram as well as a theory explaining the large observed variations in ice strength (Assur, 1958; Anderson, 1960; Anderson and Weeks, 1958; Weeks and Anderson, 1958; Butkovich, 1956, 1959). A sense of the varied projects completed under this program can be found by examining many of the papers included in the two volumes edited by Kingery (1962, 1963).

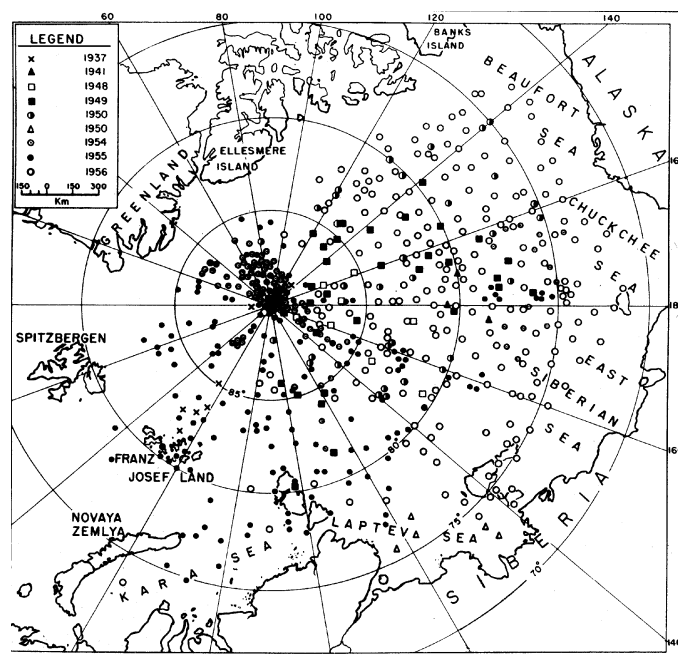


Fig. 2. Soviet ice landings, 1937 through the late 1950s. Reproduced from Leary and LeSchack 1996, *Project Coldfeet*, Naval Institute Press.

NARL entered the sea ice picture at about this time, by supporting Ice Station Alpha during its 8-month drift in 1957-58. Alpha was an ice floe station in the Arctic Basin that was deployed as part of the US International Geophysical Year (IGY—see Britton, this volume) program. The overall operation was rewarding scientifically, especially considering the logistical constraints at the time. Studies completed at the station provided the classic description of the structure and salinity profile of multiyear ice (Schwarzacher, 1959). They also provided an improved description of the surface heat and mass balance (Untersteiner, 1961, 1964a; Badgley, 1966) that ultimately led to the multiyear ice model of Maykut and Untersteiner (1971). The role of the summer fresh water layer in affecting sea ice characteristics was also investigated (Untersteiner, 1964b) and measurements were taken of the temporal variations in the velocity of longitudinal plate waves traveling through the local sea ice (Hunkins, 1960). In addition, the drift observations made on the station, when combined with earlier Russian ice station observations and observations from beset ships and ice islands such as T-3 (Fig. 3), were useful in stimulating the modeling studies of Reed and Campbell (1962) and Campbell (1965). These models were important early steps in a long series of studies (Campbell, 1968) ultimately leading to the sophisticated models that are used today. The operational experience gained during the lifetime of the station also supported the conclusions reached by the Russians in 1937-38 that long-term



Fig. 3. Ice Island T-3 in summer 1973. Carl Wales taking a sunsight for positioning. T-3 was then in the vicinity of Ellesmere Island. Note rocky rubble piles in the background. Photo, courtesy of Carl Wales.

field operations could be successfully based on the ice. A collected volume of varied work carried out on Ice Station Alpha has been compiled by Cabaniss et al. (1965). In case anyone is surprised that I have not mentioned work carried out on Ice Island T-3, that station was an effective platform for oceanographic and meteorological studies and a useful drift marker, but there appears to have been little direct sea ice work carried out from it.

Studies on Alpha led to later work on Station Charlie (Figs. 4, 5) and on the ARLIS stations that contributed the first careful descriptions of brine drainage and crystallographic features (Bennington, 1963, 1967; Knight, 1962). Those, in turn, led to improved brine drainage and salinity profile models (Martin, 1974; Untersteiner, 1968; Cox and Weeks, 1988). In addition, studies on ARLIS II by Smith (1964) showed that large areas of this ice island were essentially a single



Fig. 4. Capt. James F. Smith (USAF) and Max C. Brewer at establishment of Ice Station Charlie, 13th April 1959. Reproduced from Leary and LeSchack 1997, *Project Coldfeet*, Naval Institute Press.



Fig. 5. C-124 unloading a grader on Ice Station Charlie in May 1959. Photo, James F. Smith, courtesy of William M. Leary.

giant crystal (Fig. 6), although the generality of this observation was not appreciated at the time.



Fig. 6. Digging and ice hole on ARLIS V, summer 1970. Photo, Brian Shoemaker.

The successor to these types of operations in the far offshore was AIDJEX (Arctic Ice Dynamics Joint Experiment) which operated from 1970 to 1976 (Fig. 7). This multi-faceted project has been, in my view, the most successful scientific operation carried out in the Arctic Basin as of the time of the writing of the present paper. Its purpose was to build on the modeling attempts of individuals such as Campbell and Reed by advancing model development as well as by producing the data required for model verification. The experiment consisted of two pilot studies plus a year and a half multi-station main experiment. Results of the project include the concept of the ice thickness distribution, an idea essential to future model development in ice dynamics (Thorndike et al. 1975), and the realization that in the Arctic Basin the surface wind stress on the pack ice could be successfully estimated from the geostrophic atmospheric pressure field



Fig. 7. Open lead beneath mess hall at AIDJEX Big Bear Camp, summer 1975. Photo, Brian Shoemaker.

(Brown, 1980, 1981). AIDJEX also contributed valuable mechanical, aerodynamic and modeling insights concerning the role of pressure ridges in affecting pack ice behavior (Parmeter and Coon, 1972; Parmeter, 1975; Arya, 1975). In addition AIDJEX started the series of developments that led to the Arctic Data Buoy Program. This program (Untersteiner and Thorndike, 1982) which continues to this day, has made a major contribution to the understanding of the drift of pack ice in the main basin resulting in simple but effective ice drift Predictors as well as of stochastic ice motion analyses (Colony and Thorndike, 1984, 1985). Finally AIDJEX included the first combined remote sensing - ground truth study carried out on sea ice. This effort would ultimately lead to the more confident interpretation of satellite-borne passive microwave observations of sea ice in both polar regions (Campbell et al. 1974, 1978; Campbell et al. 1984, Parkinson 1991; Comiso, 1991; Gloersen and Campbell 1991; Gloersen et al. 1992).

While work at the drifting stations focused on pack ice behavior, work in the near-vicinity of NARL and along the coast tended to deal more with ice as a material. One of the more important early studies was by Peyton (1966) who realized that the lower half of the fast ice offshore Barrow was composed of crystals having essentially identical orientations over distances of at least tens of metres, a fact that he utilized to study the changes in failure stress as a function of crystal orientation. In addition, groups such as NCEL and CRREL studied sea ice strength (Dykins 1962, 1971) and carried out investigations into pressure ridge characteristics (Kovacs 1972, 1976; Kovacs et al. 1973; Hibler et al. 1972; Hibler and Ackley 1973).

An added impetus to the nearshore studies came from the OCSEAP (Outer Continental Shelf Environmental

Assessment Program) project. OCSEAP's task was to provide the varied information required for oil and gas leasing and operations along the arctic coast; in short to provide definitive answers to questions that are still being debated today (Fig. 8). OCSEAP's ice related programs included *in situ* studies of ice mechanics at NARL (Shapiro et al. 1990), of nearshore ice motion north of Prudhoe Bay at Narwhal Island (Weeks et al. 1977), and of descriptions of near-coastal ridging (Kovacs 1983; Kovacs and Sodhi 1988). As a result of the effective air support program carried out by OCSEAP, Weeks and Gow (1978, 1980) were able to sample crystal orientations in the lower portions of ice collected along essentially the entire Arctic coast of Alaska. This study built on the alignment observations of Peyton and of Smith mentioned earlier as well as earlier work by Russian investigators (Cherepanov 1971). It also resulted in a simple explanation: the crystal orientations were controlled by the mean current direction at the ice-seawater interface.

The OCSEAP program also investigated gouging of the sea floor by sea ice (Fig. 9). This work by the US Geological Survey resulted in detailed observational data sets of gouging frequencies and spacings along the Beaufort coast (Barnes and Reimnitz 1974; Barnes et al. 1978; Reimnitz and Barnes 1974) as well as a probabilistic model for interpreting the data (Weeks et al. 1984). These studies are particularly pertinent today with the proposed development of offshore sites to the north of Prudhoe Bay in that costs associated with pipeline burial are a major determinant of the overall cost of offshore oil production.

After the completion of OCSEAP, sea ice activities supported by NARL declined. The reasons were twofold: 1) the Laboratory's management was in transition between the Navy and the local Barrow community and 2) the primary Arctic problem facing the Navy (i.e. Soviet submarines) had shifted to the eastern Arctic. It is only within the last few years that ice related research activities have started to revive. This revival is primarily because investigators associated with recent ONR research initiatives in ice mechanics and in the electromagnetic properties of sea ice have found NARL to be a cost-effective location for field operations. Here, I shall only mention some of the results of the ice mechanics initiative because the results of the electromagnetics program are not, as yet, published.

The Ice Mechanics initiative focused on attempting to bridge the gap between the several different scales on which sea ice properties are considered. There were two

<i>Location</i>	<i>Date</i>	<i>Major features</i>
<i>Along beach at NARL</i>	<i>July 4-6, 1975</i>	<i>Offshore boundary of fast ice sheet moved shoreward about 250 m. Extensive ice pile-up and ride-up along about 2.5 km of beach.</i>
<i>Along beach at NARL</i>	<i>June 30, 1975</i>	<i>Fast ice sheet moved 15-25 m shoreward. Ice pile-up, ride-up and overthrusting along the same area as 1975 event.</i>
<i>City of Barrow</i>	<i>Dec. 30, 1977</i>	<i>Ice advanced up the beach on a 725-m front; maximum advance of 35 m. Ice pile-up along the entire front.</i>
<i>Point Barrow</i>	<i>Dec. 30, 1977(?)</i>	<i>Small ice pile-up on Chukchi Sea side of Point Barrow.</i>
<i>Tapkaluk Island</i>	<i>Late January 1978</i>	<i>Ice advanced along a 900-m front and overrode the island in several locations.</i>
<i>Martin Island</i>	<i>Late January 1978</i>	<i>Ice advanced onto island about 55 m along a 215-m front.</i>
<i>Igalik Island</i>	<i>Late January 1978</i>	<i>Ice advanced 105 m and overrode the island along a 400-m-wide front.</i>

Fig. 8. Ice pile-up and ice over-ride events along Chukchi and Beaufort Sea coasts near Barrow, 1975-78, summarized in Shapiro et al., 1984, and typical of applied questions raised during OCSEAP studies. Reproduced from Barnes et al. (eds.) 1984.

different aspects to the program: 1) the pack ice based program dealing with the scales from 100 m to 100 km (interactions between floes to large aggregates of floes); and 2) the materials science program dealing with scales from sample specimens to the size of individual floes. These programs have examined the effects of both the size and the structure of the sample on mechanical property measurements, on the large differences in crack propagation velocities with changes in ice type and structure, and finally on the interactions between propagating cracks and brine drainage channels. A variety of papers dealing with these subjects can be found in the results of a conference on ice mechanics edited by Dempsey and Rajapakse (1995).

The pack ice program has also produced interesting approaches to measuring residual as well as regional stresses within the pack, the development of rheological models for dealing with pack ice that take the orientation and distribution of leads as well as the variations of ice thickness into account, the identification of discontinuities in the ice deformation fields of the Chukchi and Beaufort Seas that appear to be tied to the boundary conditions as specified by the coastlines, and the importance of thermal stresses in causing crack formation in sea ice. Some of these results have recently been published in a special section of the *Journal of Geophysical Research* (Weeks and Timco 1998).

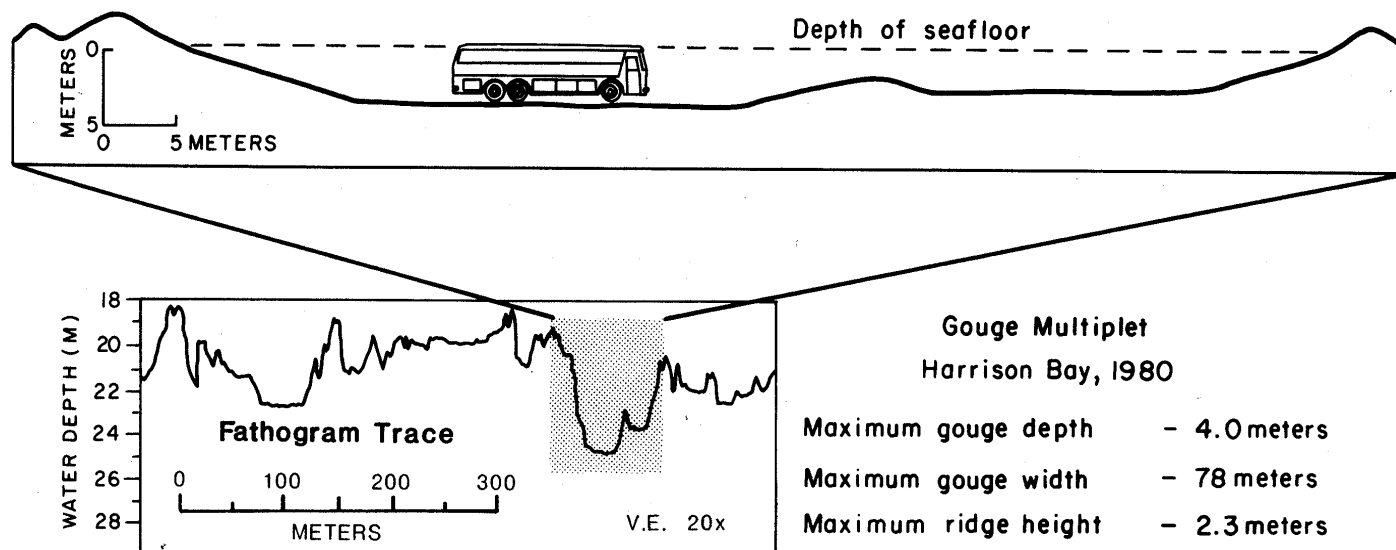


Fig. 9. Seafloor gouging by ice keels in outer Harrison Bay, 1980. Distortion of vertical exaggeration from fathometer trace is removed for the expanded section that is depicted in relation to a motor coach. Reproduced from Barnes et al. (eds.) 1984.

LAKE ICE STUDIES

By studying North Slope lakes, Knight (1962) clearly documented the fact that lake ice sheets can have more than one type of basic structure. The detailed mechanisms involved are still a matter of discussion today (Weeks and Wettlaufer 1996).

One activity of OCSEAP was to fly side-looking-airborne-radar (SLAR) to examine ice movements along the coast. Surprisingly when one examined the edges of these SLAR swaths, covering numerous ice-covered lakes, striking changes were observed in the strength of the radar return from the lakes. This was considered to be particularly unusual in that, at that time, radar was generally thought not to penetrate the ice. Simple observations of the changes in the patterns of the returns with time, however, strongly suggested that penetration was indeed occurring and that the patterns revealed whether or not a given section of a lake was frozen to the bottom (Sellmann et al. 1975; Weeks et al. 1977, 1978; Mellor 1982). Calculations coupled with field verification have since shown that there is no discrepancy between observation and theory and that this simple explanation is correct. Recent work (Jeffries et al. 1993, Wakabayashi et al. 1993a, 1993b) using data collected by the ERS-1 synthetic aperture radar satellite has greatly expanded the available coverage of North Slope lakes allowing identification of lakes that can be considered to be potential year-round sources of water. If further oil and gas development occurs within NPR-A this information should prove to be very useful. In fact based on this radar technique, maps of a significant portion of the North Slope

showing which lakes are unsuitable as a year-round water sources are already available (Weeks et al. 1981).

CONCLUSIONS

It is interesting to speculate on the future role of NARL in sea ice related studies. Speaking as an individual who has completed numerous sea and lake ice related operations based at or supported by NARL, I find that the location still has striking advantages provided that one wishes to study first year ice (some years multiyear ice is also locally available). One can easily drive and sometimes even walk to many potential research sites. Different types of first year ice consistently occur at specific locations allowing one to work either in a coastal or a lagoonal environment. Arrangements can also be made for cold rooms within walking distance of the beach. The housing and dining accommodations are both comfortable and inexpensive (for the Arctic). Finally, members of the community are friendly, and they understand what is being done and why. The only item currently in short supply is adequate laboratory space; a problem that will possibly disappear in the foreseeable future. Couple these advantages with a major airport ready access via several scheduled jet flights per day, and easily arranged charter aircraft support if required and you have research opportunities clearly unequalled at any other site in the US Arctic or elsewhere on the edge of the Polar Basin.

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Marine Biological Studies at NARL

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ABSTRACT: Within a few years of the Navy's establishment of its Laboratory at Barrow, arctic marine biology matured from being expeditionary science to more resident-based research. The transition involved and strengthened the University of Alaska, while increasing participation by other institutions as well. Highlights are noted from this period of maturation.

Key Words: Ice algae, arctic primary production, Stefánsson, Boulder Patch, stable isotopes

Consider the Foreword by Isiah Bowman to the book "Problems of Polar Research," published by the American Geographical Society (Bowman 1928), in which he said:

"Polar exploration has reached an advanced stage of intensive search in critical places. So much is now known that the unknown is rather closely localized. Airplane and airship have vastly increased the speed of surface reconnaissance, and blank areas of substantial size will soon disappear."

Bowman's optimistic viewpoint is no longer held, and we now believe that the polar seas are the last largely unexplored major oceanic area. Of course, progress has been made, but we recognize that we do not have adequate access to the Arctic and that there are problems with sampling here. New findings are still emerging and there is no end in sight. Research at or out of the Naval Arctic Research Laboratory (NARL) provided the backbone of our marine biological knowledge of the Arctic. Capitalizing on its ideal location at the northernmost tip of Alaska, NARL served as a base for fieldwork along the local shoreline areas of the Chukchi and Beaufort Seas, and as a jumping off point for work over the Arctic Basin. For the access provided to the regions farther north, primarily through support of drifting ice stations, NARL played a key role. Marine biological collecting began long before the laboratory was established, of course, but its continuity hinged on the cooperation between Barrow residents and early expeditions to the region.

More than a century ago, the International Polar Expedition (Ray 1885) centered its activities at Barrow, resulting in some of the earliest collections. For the offshore areas (Nansen 1928), it was assumed that the Arctic Ocean was very unproductive, except in the coastal areas. Stefánsson (1928), of course, knew better, since his expeditions lived by hunting hundreds of miles from land over deep water, finding that the seals became fatter as they progressed into the region previously considered devoid of animal life. His finding was confirmed by the recent observation during the 1995 polar transect that polar bears wander all over the polar basin, all the way to the north pole. Indeed, where there are polar bears, inevitably there are also seals.

The work mentioned above was all expeditionary. With the establishment of the Arctic Research Laboratory at Barrow, Alaska itself improved logistic support, and provided new opportunities for research. The early marine biological work involved collecting and identifying organisms, and included biogeographical analysis. The International Geophysical Year and drifting ice stations accelerated marine biological work in the polar basin. Drift Station ALPHA was an important platform. Biological collections had been made from Ice Island T-3 between 1952 and 1955, and also from ARLIS I and ARLIS II, producing the first substantial polar basin biogeographic information. The taxonomic work on these collections involved expertise from a variety of institutions.

A study of arctic crustaceans was carried out in 1952 and 1953 (Mohr 1953, 1959; Mohr *et al.*, 1961), and extensive collecting was done along the coastal shelf (Wilimovsky 1953, 1954). Mohr and Tibbs (1963)

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discussed the effects of the arctic conditions on biological systems, pointing out that organisms have no common morphological characteristics that permit generalizations about the effects of cold. They recognized that there is evidence for enzymatic adaptation to life close to 0°C. Wilimovsky (1963), in discussing the paper by Mohr and Tibbs, pointed out that ice is like an inverted shoreline, and that ordinary collecting techniques are inadequate for the Arctic. He emphasized that the arctic basin is not a biological desert, and listed birds and mammals found there. He argued that the list of fauna is dominated by homeothermous or warm-blooded forms, and that there is only one fish in the main portion of the basin — *Boreogadus saida* — the Arctic cod. He also noted that cryo-biotic relationship has a definite association with type, age, and extent of ice, and that a cycle of life exists and is probably associated with old ice forms. This is all well in accord with our present understanding. Hulsemann and coworkers collected pelecypoda, bryozoa and radiolaria in the region (Hulsemann 1962, 1963; Hulsemann and Soule, 1962).

Primary production in the Arctic was little known at that time. English (1961) initiated the experimental approach when he made the first primary production measurements over the polar basin from Drift Station ALPHA, finding extremely low rates in the water column. My own involvement with marine research at Barrow started when I began to work with Rita Horner to measure primary production by ice algae. Horner (1969) had been working for some years on the phytoplankton species in the area, having completed her dissertation on the subject. The presence of ice algae in arctic ice had already been documented by Nansen (1906), and later arctic ice algae had been studied by Apollonio (1965), and by Meguro and his colleagues (Meguro *et al.*, 1966, 1967). Although it is now well recognized that ice algae and associated communities dominate the lower trophic production at very high latitudes over the polar basin, at that time we did not know whether ice algae production extended out into multi-year ice. No accurate measurements of primary production had been conducted, because of the difficulty of losing the lowest layer of ice when we extracted cores from the ice, and also exposing the very low-light adapted cells to surface light. We used divers to install chambers into the ice and to inject tracers for the measurements, without disturbing the algae—a method that worked very well (Clasby *et al.*, 1973). Using these techniques, we were able to follow the development and decline of a distinct spring bloom in the ice (Clasby *et al.*, 1976). Now, the annual cycle of the ice algal community is well known from Barrow,

while there is only incomplete information for most other polar stations. Access from shore played a large part in our finding that ice algae played an important role in the annual production.

There are always new surprises, such as the discovery of the Stefánsson Sound Boulder Patch, with its rich and diverse macrophyte and invertebrate flora and fauna (Dunton and Schell, 1986, 1987). OCSEAP research support helped confirm the role of ice gouging in keeping most other Beaufort Sea sediments bare. The Stefánsson Sound boulders, protected from ice movements inside barrier islands, provide a stable environment, and accommodate a diverse and rich community of organisms.

Today, various research activities based in Barrow are underway. Modern techniques, such as acoustics, the use of stable isotopes (e.g., Schell *et al.*, 1989), satellite-tracking of animals and other remote sensing, are expanding the approaches available for studying components of the marine ecosystem.

We have reviewed enough highlights to challenge the viewpoint expressed by Bowman (1928) quoted in my first paragraph. There is much yet to be discovered. Shore bases will always be needed. Marine biologists have long promoted the need for surface access to arctic waters, a need still not addressed adequately. We have a submarine-based research program underway, and a repeat of the Nansen drift is still a hoped-for goal. As we come to recognize that the Arctic is not an isolated remote area, but rather an area that is integral to the global oceanic and atmospheric system, and one that is surprisingly vulnerable to pollution, the imperative for a vibrant and active research program will be obvious. UIC-NARL, as this facility is known today, still has a role to play.

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NARL-based Terrestrial Bioenvironmental Research including the U.S. IBP Tundra Biome Program, 1957 to 1997

Jerry Brown¹

ABSTRACT: Research on soils, ecology, hydrology and permafrost at NARL over the past 40 years is described based on the author's personal involvements. Individual, disciplinary research projects funded largely by ONR gave way to the interdisciplinary IBP Tundra Biome ecosystem research approach of the 1970s and funded by NSF. Also during the 1970s, research on tundra impact and recovery was undertaken from Barrow and Prudhoe Bay in the NPRA, oil fields and along the haul road. Terrestrial research at Barrow was greatly diminished in the 1980s, but returned in the 1990s as global change questions and new funding emerged. The NOAA GMCC/CMDL monitoring program for trace gases began in the 1970s and continued uninterrupted to date. In the 1990s the need for a permanently protected area for research was recognised and the local land owner (Ukpeagvik Iñupiat Corporation) designated 7466 acres as the Barrow Environmental Observatory (BEO), and to be managed by the Barrow Arctic Research Consortium (BASC).

Key words: ecology, ecosystems, soils, permafrost, hydrology, Tundra Biome, RATE, IBP, BEO, Barrow, Prudhoe Bay, Haul Road

The book commemorating NARL's 25th anniversary ended with the sentence: "Hopefully, in 1997 NARL will still be able to crow about its accomplishments of the then past quarter century" (Britton, 1973: 224). NARL is still here and we are here to "crow" about not only the past 25, but all 50 years. Unlike the 25th, this anniversary has been organized by the NARL Barrow community, and I am grateful to be included. I was invited to talk about the Tundra Biome program of 1970-1974. Because this occasion marks my 40th anniversary at NARL, I feel obliged to start with my own scientific beginnings and briefly wind the way to the present with a glance into the future. My emphasis is on the history of research sites around Barrow and their future significance. Several chapters in recent books place the Barrow activities in scientific context with other programs in Alaska and the North Slope (Shaver, 1996; Hobbie, 1997). Other contributors address the OCSEAP, NOAA, DOE, USGS and other agencies' programs. I will focus on those activities in which I have been most closely involved.

My NARL experience began when I arrived as an undergraduate from Rutgers University under the mentorship of J. C. F. Tedrow and Lowell Douglas and the AINA-ONR grant. Jim Drew had just finished his doctoral dissertation on the soils of the Barrow region.

His dissertation included a map and classification of the soils and polygons; a recently prepared, color-coded digitized version of the old paper copy is presented for incorporation into the North Slope Borough's GIS. Lowell Douglas had the outrageous notion to measure *in situ* soil respiration and decomposition across a moisture gradient. I spent the summer 1957 weaseling to and from the beach ridge, the site now occupied by NOAA's CMDL, changing flasks and measuring carbon dioxide. Trace gas analyses and carbon budgets have come a long way since ONR invested in this pioneering research (Kelley, this volume). I returned to Barrow in 1958 and was shuttled around the central and eastern Brooks Range by the NARL float- and ski-equipped Cessna 180s in pursuit of soil forming processes of the well-drained, glaciated and bedrock terrains; the Okpilak-Jago lakes being home-base camps for three long summers.

When my dissertation was nearly completed, I accepted a position at CRREL in 1961. A basic pedological and ecological research program at Barrow became the focus for a team effort, which built on the Laboratory's multidisciplinary legacies of the 1940s and 1950s (Reed and Ronhovde, 1971; Elsner, this volume). Phil Johnson and I established a research transect and plots (Figs. 1, 2) from Elson Lagoon into Central Marsh bordering Wohlschlag Slough (Brown, 1969). Unlike many other plots scattered over the Barrow landscape, our plots from the early 1960s are

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Fig. 1. Aerial view of CRREL study area between Elson Lagoon and Central Marsh.



Fig. 2. Spring runoff into Central Marsh Slough along CRREL Transect; this is the site of the four-year hydrological study.

still in use today under the NSF-Arctic System Science (ARCSS) program. The legacy of continuous work along the transect played an important role in the delineation of the Barrow Environmental Observatory (BEO). CRREL colleagues Paul Sellmann, Robert Lewellen, Al Tice, Larry Dingman, and many Army officers and enlisted personnel participated in many detailed studies. The Barrow peninsula was mapped at 0.5-m contour intervals, drilled and cored to 25 m, radiocarbon-dated for a 25 000-year history (Fig 3), its watershed hydrologic balance measured over four summers, and active layer chronology described. Complete documentation of this work can be found in the CRREL reports, bibliography and library. Our nearly year-round activities placed heavy demands on NARL equipment, which Kenny Toovak and Frankie Akpik supplied and operated (Fig. 4). Among Frankie's finest accomplishments was to auger holes in permafrost to a depth of 5 m with a diameter of 1 m. Without these borings a three-dimensional view and sampling of permafrost and buried ice wedges would have been impossible. The memorable October 1963 flood interrupted our activities for a few days.



Fig. 3. Underground view at 4-m depth of "CRREL ice mine" located at the end of the powerline between Footprint Creek and Browerville.



Fig. 4. NARL drilling equipment used to core Barrow permafrost by CRREL project in the 1960s.

By the late 1960s Congress had passed Public Law 91-438, providing the basis for U.S. participation in the International Biological Programme, and, of equal importance, mandating federal agencies to provide *in kind* support. Large regional programs were designed, but funding at the National Science Foundation initially provided for the start of only four Biomes (Grassland, Desert, and Deciduous Forest, and Coniferous Forest Biomes). Oil discoveries at Prudhoe Bay, however, provided added rationale for a new tundra research program and the beginning of the Tundra Biome. Barrow had already proven itself a test bed for an unusual combination of basic and elementary applied research, especially because of the long-term observational base, which allowed investigators to document such changes as shoreline erosion (Fig. 5a,b).

Building on the rich heritage of ecological research at Barrow, a one-year study was launched adjacent to

Footprint Creek in summer 1970. The Barrow sites straddled Footprint Creek (Fig. 6a, b), a location shared for a short period with the Smithsonian radiation program and previously occupied by the Air Force's "Cake Eater" project. The site was chosen because large numbers of investigators commuting to it could be carried by truck, and because it had access to the existing electric power line. Weasel transport to off-road sites was considered unrealistic for such large numbers of investigators. The shuttle became a daily part of Riley Sikvayugak's responsibilities. Electrical power was essential for the data recorders and instruments. NARL's Director, Max Brewer, had

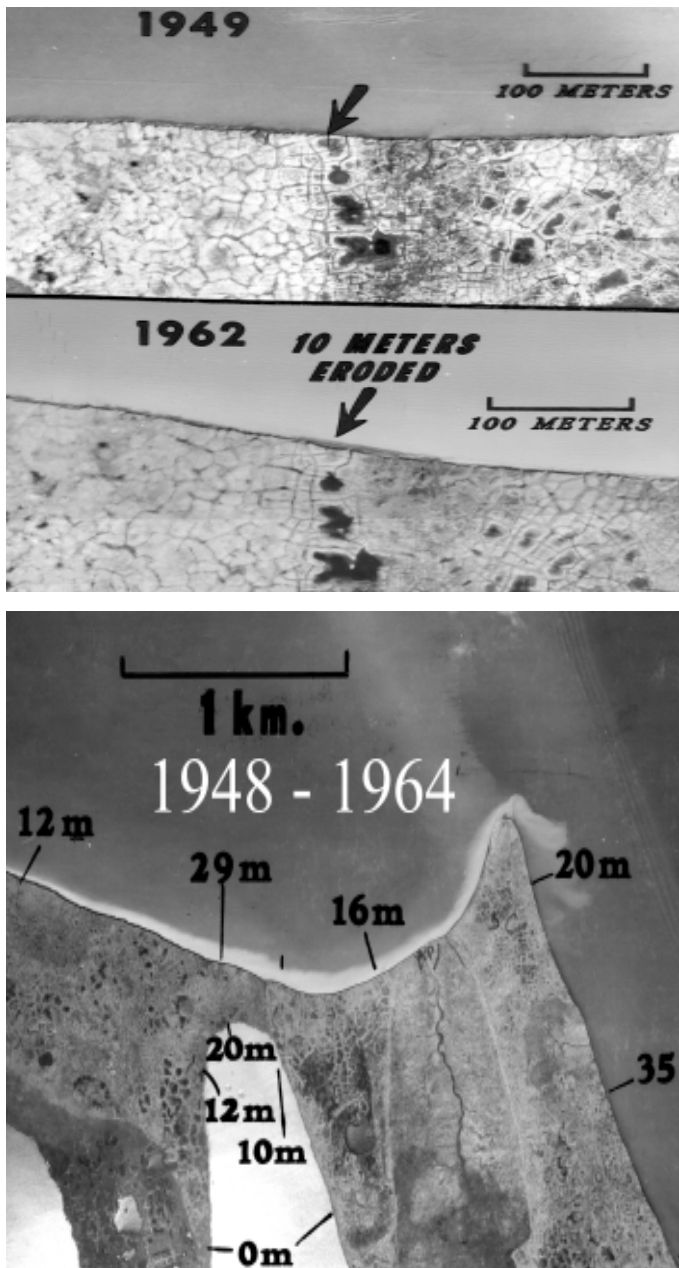


Fig. 5. Shoreline erosion along the southern shore of Elson Lagoon: a) example of a 13-year span recorded by aerial photography; b) measured rates of erosion over a 16-year span at the head of East Twin Lake. (See also, Carson, this volume.)



Fig. 6. Aerial views of the Tundra Biome sites: a) oblique, looking toward Chukchi Sea (background). Footprint Creek cuts across the main sites. The wanigans served as field laboratories located along the powerline. Footprint Lake drainage is in the lower left; Sites 1 and 2 are in the center along the snow-drifted creek; b) vertical aerial view of Footprint Creek, its crossing by Cakeater (Gaswell) road, and Sites 1 and 2 on either side of the creek.

arranged for the power line to be extended across the site for the 1970 season. John Schindler continued the daily NARL support for the duration of the program. Symbolically the last power pole nearly reached the ice wedge mine (Fig. 3) that I had excavated in 1963 and radiocarbon dated at a minimum of 14 000 years old. That mine is located on the high ground overlooking Barrow and the nearest (but in those days still distant) edge of Browerville.

Emphasis was on surface perturbations and establishing a series of manipulations and control plots (Figs 7a, b; 8a-c). Thirteen individual, but coordinated, NSF and CRREL projects were initiated at Barrow with other projects along the pipeline route between Prudhoe Bay and Fairbanks (Fig. 9). Before the end of 1970, a comprehensive report on the structure and function of cold-dominated ecosystems was published and the justification and planning of the Tundra Biome program for 1971 field season was well underway. The NSF National Science Board approved the program and the U.S. became an official participant of the IBP Tundra Biome program, which eventually included an international network of some 15 high latitude and alpine sites. During summers 1971-1974 some 65 projects and support activities and over 200 personnel conducted integrated research at Barrow (see attached list). Barrow-based scientists shuttled to industry-supported sites at Prudhoe Bay; another 20 projects conducted comparative research at Prudhoe Bay and at alpine sites at Eagle Summit, Alaska, and Niwot Ridge, Colorado. Three general objectives shaped the U.S. program:

- (1) to develop a predictive understanding of how the tundra system operates;
- (2) to obtain the necessary database from cold-dominated ecosystems so their behavior could be modeled; and
- (3) to bring basic environmental knowledge to bear on problems of degradation, maintenance and restoration of cold-dominated ecosystems.

We built what I like to think was a positive leadership structure from within the diverse participants in the Tundra Biome. The Barrow summer programs were under Larry Tieszen's overall site directorship, and the aquatic or pond sites under John Hobbie's supervision. Other science management responsibilities were shared at the subprogram level by Steve MacLean (consumers), Fred Bunnell (decomposition, soils and nutrient flux), Phil Miller (modeling and synthesis), and Brown (abiotic and central management). The only year-

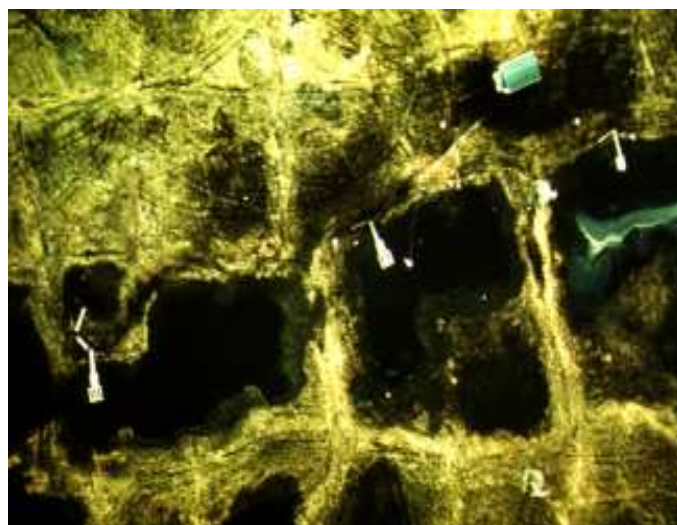


Fig. 7. Tundra Biome ponds: a) aerial vertical view; b) sampling enclosures and walkways.

round component was Gunter Weller's micrometeorology project. In addition to NSF, ONR and CRREL support, DOE (previously AEC and ERDA), the State of Alaska, and the petroleum industry provided financial support. The University of Alaska provided in-state field coordination through the Biome Center (David Witt) and data and computer services (Geophysical Institute). The CRREL editorial staff headed by Steve Bowen deserve special recognition for the high-quality production of the voluminous Biome publications and supporting documentation.

It is impossible to summarize all the many scientific accomplishments of the Tundra Biome in this account.

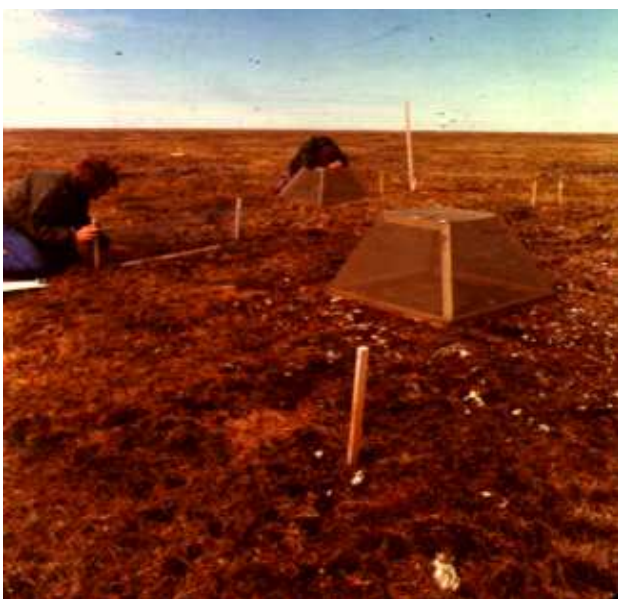


Fig. 8. Examples of Tundra Biome terrestrial plots and studies: a) heated soil experiment; b) vegetation plot with insect trap; c) mast and labs for sampling and analyzing carbon dioxide flux near North Meadow Lake.



Fig. 9. Several Tundra Biome perturbation studies, illustrated: a) Cape Simpson oil seeps serving as natural laboratory (caribou that succumbed in tar-like pool after entrapment); b) CRREL off-road vehicle studies (Rolligon).

Nevertheless, being able to look back on the experience after a couple of decades and with the help of Larry Tieszen makes it possible to highlight a few achievements that have stood the test of time well. Hindsight also allows us to trace some of the people ('alumni') of the Tundra Biome and their ideas through activities and programs descended from the Tundra Biome.

- NOAA-CMDL reminds us constantly of Barrow's importance to the documentation of both the rate of increase in global atmospheric carbon dioxide, and of the large seasonal oscillations expressed by this gas at high latitudes in the northern hemisphere. The IBP project contributed substantially to Barrow's acknowledged importance today by making one of the first successful assessments of net annual fluxes of carbon. Our carbon flux budget combined pioneering assessments of exchange, chamber monitoring of selected species of primary producers, and harvest measurements of biomass accumulation of carbon. All components of the flux were

measured within the same landcover and in the same year. IBP results also emphasized the extent to which low soil temperature, poor drainage, and permafrost limit decomposition as well as determining rates of plant growth and nutrient uptake.

- Modeling proved to be a valuable tool in directing and integrating inter-disciplinary research. More recent circumpolar studies have emulated the U.S. Tundra Biome program's inter-disciplinary approach (e.g., Norton and Weller, this volume) which in turn has enhanced cooperative and international projects, some of which are ongoing even today.
- The emphasis on basic research, process-oriented modeling, and responsive publishing resulted in a highly successful program that not only contributed to the general advancement of ecosystem science, but also fostered the maturation of scientific leadership to the benefit of many institutions and disciplines.
- The program opened opportunities for women in science with many female graduate students, assistants and senior investigators sharing the Barrow research.
- Three volumes on Tundra Biome research results at Barrow and two major reports on Prudhoe Bay were published by 1980. Major U.S. contributions were made to six international volumes. Hundreds of papers and over 60 Master's theses and Ph.D. dissertations were completed (Brown et al. 1983). Bound copies of the complete documentation of the program are on file at the NSF, the University of Alaska's Rasmuson Library, and at CRREL (see references and appendix).

The immediate successor to the Tundra Biome program was the NSF-sponsored, three-year program starting in 1975, called Research on Arctic Tundra Environments (RATE). Its terrestrial program was centered at Atkasuk; the aquatic site was at the newly established Toolik Lake camp along the pipeline haul road. All logistics for Atkasuk came from NARL in support of a team of 20 scientists who occupied an upgraded Meade River NARL camp to the east of the

old runway. The research had three parts: (1) landforms, soils, vegetation and herbivore populations; (2) physiological response of plants; and (3) experiments to test hypotheses on the impact of herbivory on plants, vegetation and soil. To simulate caribou grazing, fistulated reindeer were flown in from the University of Alaska's Cantwell Research Station (Fig. 10). George Batzli served as the program coordinator for the program, for which CRREL continued to provide administrative support. Major results were presented in a special issue of *Arctic and Alpine Research*. The program demonstrated a strong relationship between plant growth form and herbivory. In addition to NSF support, DOE provided modest financial support, but unlike the Tundra Biome program, there was a modest charge to NSF for ONR-NARL logistic support, subsidized by the Naval Petroleum and Oil Shale Office. The RATE research at Toolik was logistically supported from Fairbanks and served as the scientific and logistic forerunner of subsequent aquatic and terrestrial programs (Shaver, 1996).

The exploration of the Naval Petroleum Reserve-Alaska provided another opportunity for some of the Barrow and Atkasuk investigators (Tundra Biome and RATE 'alumni') and their colleagues to visit and study the old PET-4 drill sites and to assess natural recovery of heavily perturbed terrains. A series of CRREL reports documents degrees of degradation and rates of recovery at Oumalik, Fish Creek and other sites, including Cape Thompson (Figs 11, 12). Our colleague Kaye Everett played a major role in the NPRA studies as did Dan Lawson and Bruce Brockett from CRREL, and the University of Colorado geobotanical team headed by Pat Webber. These studies were logical and complementary extensions of the Barrow-based programs of the 1960s and 1970s



Fig. 10. Reindeer and Jeanette Trudell at Atkasuk site for the RATE Program, one of the successors to the Tundra Biome.

and were greatly facilitated by Max Brewer and the U.S. Geological Survey staff in Reston, Virginia. The Air Force's Legacy Resource Management Program funded the Institute of Arctic and Alpine Research (INSTAAR) to perform a somewhat similar impact study in the early 1990s in the vicinity of the Barrow DEW site.

The 1980s witnessed a lull in field programs for major terrestrial research at Barrow, although individual projects such as those led by Dwight Billings and Kim Peterson focused on carbon flux and vegetation succession. The Arctic Research and Policy Act of 1984 (Public Law 98-373) brought some of us back to Barrow in October 1986 for the review by residents of the first Arctic Research Plan. The 1990s saw a resurgence in ecological research at Barrow, in part catalyzed by concerns for climatic and global changes. Walt Oechel occupied the IBP Tundra Biome intensive site and several other sites to re-measure trace gas flux. When the IBP site was platted for residential subdivision



Fig. 11. Light-weight permafrost drill being transported to NPR-A Fish Creek and Oumalik sites for CRREL-coordinated tundra recovery projects.



Fig. 12. Aerial oblique view of pipeline and haul road crossing of the upper Kuparuk River; this was later to become the site for many stream and terrestrial investigations, including the Toolik LTER program.

out along the Gaswell or Cake Eater Road, the concept and previously discussed need for a research preserve or observatory re-emerged. The Barrow Environmental Observatory (BEO) was approved by the UIC in 1992. Since then, the NSF-supported Arctic System Science (ARCSS) program and component projects provided support for the establishment of the permanent 1000-m grid within the BEO, support for the International Tundra Experiment (ITEX), several active layer studies, and year-round dedicated laboratory space at NARL's Building 360.

The benefits of interdisciplinary teamwork are perhaps best illustrated by frustrations one encounters while trying to work in its absence. Recent experience provides an anecdote. Starting in 1991, colleagues Kaye Everett, Fritz Nelson and I began re-measuring active layer thickness on the 1960s CRREL plots near Wohlschlag Slough, and on the IBP plots (Fig. 13). Much to our surprise, the average thaw was shallow in summers 1991 and 1992 (23 cm) although the summer climate regimes were comparable to deeper thaws in the 1960s (32-44 cm). It took several more summers for the active layer to reach depths considered more normal for the CRREL, IBP and ARCSS grid sites (34, 27, and 35 cm, respectively in 1994). One plausible explanation dates back to the 1950s when Pitelka and Shultz enunciated the nutrient cycling hypothesis (NCH). (Shultz, 1964) The shallow thaws of 1958 and 1959 followed the 1956 lemming high and the added insulation of the increased litter. Plant litter was also abundant in late summer 1991 and 1992; a sign of high lemming activity and litter production. Alternatively, changes in tundra soil moisture regime may have accounted for the thinning of the active layer. Unfortunately, we have few other quantitative observations from comparable sites in the early 1990s to retest these hypotheses. We missed the abnormally

warm summer of 1989 to verify the potential average historical maximum thaw at Barrow of 52 cm (Brown, 1969). These uncertainties underscore the need for a long time series of combined ecological and active layer observations at Barrow and elsewhere, to ascertain similarities and differences among tundra sites and regions over time. Such a series forms needed input to global change research. Some observations are beginning under the ITEX and Circumpolar Active Layer Monitoring (CALM) programs. Barrow represents one of the more important locations in the present 70-site CALM network.

Interactions between visiting scientists and the Iñupiat have been essential. Although most programs brought a great deal of equipment and expertise with them, we always needed local NARL help in connecting to the field sites. In the early days, our daily contacts were with the NARL staffs in the shops and front office: Kenny Toovak, Frankie Akpik and others for the vehicles, heavy equipment, and rescuing broken weasels. Although these undisputed masters of their crafts might have had good cause to grow impatient with the problems we investigators brought, their unfailing good cheer was like a welcome mat to their shops. Coffee breaks and meals in the Camp Dining Hall were always occasions for friendly exchange, and sometimes a chance to corner someone for much needed advice or help (Norton, this volume). The old lab (Building #250) and its surrounding facilities cannot be forgotten. It was these early days that fostered the commitment and respect among the Iñupiat for science and in turn generated our gratitude and appreciation for their invaluable services. We owe a great deal to those of you who served the NARL so faithfully over the years. It also should be said that a progression of NARL directors and commanders have left us with indelible memories as well as appreciation for their outstanding support.

Some interesting trends in research support and related activities should be mentioned. Until the 1960s the ONR system maintained a visible institutionalized presence of terrestrial research. Logistics support was free to the users. The NSF, based on a combination of large programs and individual grants, has maintained a presence at Barrow for almost three decades. Once established, the NOAA GMCC (now CMDL) facility has been a permanent fixture for atmospheric monitoring and cooperative research. In 1971, the USGS Water Resources Division established a permanent, recording stream gauge on Nunavak Creek and has recorded discharge annually since then. Other agencies have been in and out of Barrow on

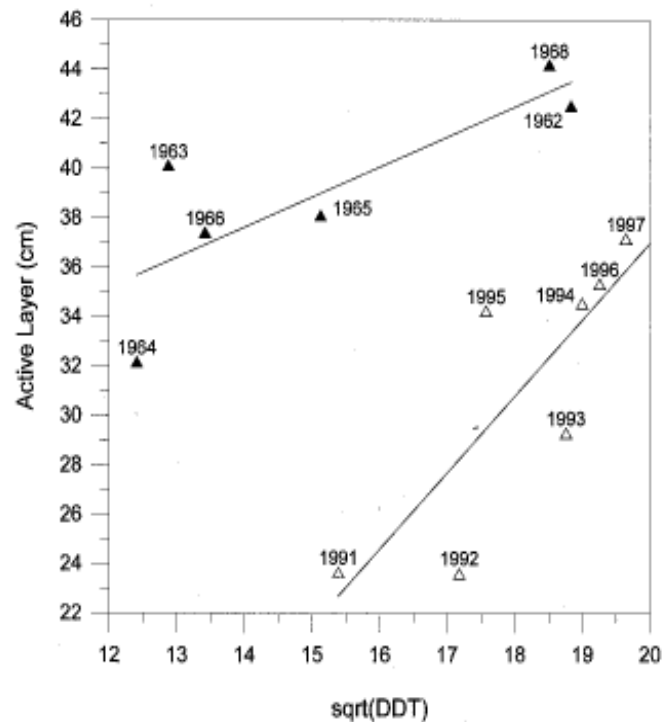


Fig. 13. Plot of active layer depths during the 1960s and 1990s, showing two distinct sets of values for the same degree-day accumulations.

short-term mission programs such as USGS, CRREL, NASA, FWS, BLM, Air Force, and EPA. For example, in the early 1990s the EPA contaminant program used the BEO to sample for baseline concentrations of contaminants in soils and vegetation. By contrast, the new DOE ARM program seems committed to a long-term program at Barrow and Atkasuk. From its beginnings, the North Slope Borough's Department of Wildlife Management and its leaders have maintained a high level of support for research, including the utilization of the Animal Research Facility (ARF) for visiting scientists and students. Tom Albert has been a bellwether for science since NARL's transfer to UIC. The North Slope Borough's GIS office has been a sustained resource. The UIC commitment to the Barrow Environmental Observatory is commendable.

During these anniversary celebrations we heard thoughts and speculations about the future of NARL. The Barrow and NSB communities need NARL for training, research, and national and international recognition. The research communities will continue to rely on the scientific heritage of the Barrow region. U.S. funding agencies, based on current missions, will fund relatively short-term projects and programs. Scientists from other countries will visit Barrow, and we can hope their purpose is to improve our still limited understanding of Nature's vagaries; not just to acquire random samples to take back home for detailed analyses. The ultimate vision for the future is an

internationally recognized BEO as a carefully managed ecosystem reserve with its interactions adjacent to the ocean, lagoon, atmosphere, lands, and Iñupiat community and their traditional lifestyles and knowledge. A private foundation or endowment would enhance the prospects for the long-term sustainability of the BEO and to fill gaps in funding cycles. The UIC-BASC partnership serves as an excellent prototype for the future.

I am certain that NARL and its derivatives will survive and prosper for another 25 years and am hopeful about fifty more years thereafter. We must rely on the younger generations of local residents and the scientific communities to justify and provide the support for NARL. Barrow, the NARL, and the BEO-Heritage Reserve should serve the United States as its principal year-round, geographically-located, arctic research center well into the 21st century.

Larry Tieszen, Tundra Biome Barrow site director, provided valuable input to this section of the paper.

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APPENDIX A. INSTITUTIONS AND SENIOR INVESTIGATORS - IBP TUNDRA BIOME BARROW SITE 1970-1974

(affiliations as in Brown et al., 1980): U.S. Institutions and Organizations

Argonne National Laboratory - Roy E. Cameron
 Augustana College - Larry L. Tieszen
 Cold Regions Research and Engineering Laboratory- Jerry Brown,
 Richard Haugen, Yoshisuke Nakano
 Chicago State University - James R. Rastorfer
 Duke University - W. Dwight Billings (deceased), Kim Peterson*
 Homer, Alaska - Jere Murray
 Johns Hopkins University - William J. L. Sladen
 Lawrence Radiation Laboratory - John J. Koranda
 Littleton, Colorado- Robert Lewellen
 Marine Biology Laboratory - John E. Hobbie, Gaius R. Shaver*
 New York Botanical Gardens - William Steere (deceased)
 New York State Department of Environmental Conservation -
 Robert E. Henshaw
 Office of Naval Research - Gary Laursen*
 Ohio State University - K. R. Everett (deceased), Emanuel D.
 Rudolph (deceased), Edmond Schofield
 Pennsylvania State University - Cecil W. Goodwin
 Ryder College - Mary L. Allesio
 Rutgers University - Aytakin Bilgin* (deceased), Lowell A. Douglas
 St. Paul Bible School - Donald A. Bierle
 San Diego State University - Boyd D. Collier, Albert W. Johnson,
 Philip C. Miller (deceased), Mitchell E. Timin
 State University of New York - Raymond G. Stross
 University of Alaska - Vera Alexander, Robert J. Barsdate, Carl S.
 Benson, F. Stuart Chapin III*, Frederick C. Dean, Charles D.
 Evans, Dale D. Feist, Patrick W. Flanagan, John J. Kelley,
 Stephen F. MacLean, Jr., C. Peter McRoy, Herbert R. Melchior,
 David F. Murray, Stephen A. Norrell, David W. Norton*,
 Kenelm W. Philip, Donald M. Schell, Larry S. Underwood,
 Keith VanCleve, Gunter Weller, Gerd Wendler, George C. West
 University of California - Rodney J. Arkley, Sally W. Chisholm*,
 Harvey F. Donner, Paul L. Gersper, Rudi Glaser, L. Jacobsen,
 Hans Jenny, Frank A. Pitelka, Arnold M. Shultz, Jawahar
 Tiwari, Albert Ulrich
 University of Cincinnati - Michael C. Miller
 University of Colorado - John Andrews, Roger G. Barry, Diane
 Ebert*, Donald A. Walker*, Patrick J. Webber
 University of East Carolina - Donald W. Stanley*
 University of Florida - Grover C. Smart

University of Georgia - D. A. Crossley, G. Keith Douce*
University of Hawaii - K. W. Bridges
University of Houston - Guy N. Cameron
University of Illinois - Edwin M. Banks, George O. Batzli
University of Michigan - Samuel I. Outcalt
University of New Hampshire - S. Lawrence Dingman
University of South Dakota - Raymond A. Dillon
University of Tennessee - David K. Smith*, Ronald Schmoller
University of Texas - James N. Cameron
University of Washington - John S. Edwards
University of Wisconsin - Brent McCown, Stanley Dodson,
Richard Prentki*
U.S. Department of Agriculture, SEA - Doug A. Johnson*, R. P.
Murrmann (CRREL), Patrick I. Coyne (CRREL),
Patrick J. Hunt (CRREL)
U.S. Department of Agriculture, Forest Service - Frederick Deneke
(CRREL)
U.S. Fish and Wildlife Service - Thomas W. Custer*, Harry N.
Coulombe
U.S. National Park Service - John G. Dennis
Utah State University - Martyn M. Caldwell
Virginia Polytechnic Institute - Robert E. Benoit, Orson K. Miller

APPENDIX B. INTERNATIONAL INSTITUTIONS AND ORGANIZATIONS IN U.S. TUNDRA BIOME PROGRAM

Arheim, Netherlands - Dirk Barel
Australian National University - Edward G. Brittain
Birmingham University, UK - Nigel Collins
British Antarctic Survey, UK - Terry V. Callaghan
DSIR, New Zealand - B. Michael Fitzgerald
Hebrew University, Israel - Uriel N. Safriel
Inland Waters, BC, Canada - Ralph Daley
McGill University, Canada - Walter C. Oechel, Bjartmar
Sveinbjornsson*
Meteorological Institute, Sweden - Bjorn Holmgren
University of Aarhus, Denmark - Tom Fenchel
University of Alberta - Palle Gravensen, John G. Packer
University of British Columbia - Fred L. Bunnell*, Pille Bunnell
Uppsala University - Steffan Holmgren
York University, Canada - Martin C. Lewis

* Ph.D. awarded as part of Tundra Biome program; not necessarily
for Barrow site.

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Reminiscences of a Naval Officer and Scientist at NARL

Captain Leonard A. LeSchack, USNR (ret)¹

ABSTRACT: In the context of history, the Navy's Arctic Research Laboratory (NARL) at Barrow, Alaska, has played important roles over the past 50 years, not only by supporting arctic science and assisting in the development of Barrow Village and the North Slope, but also in the realm of geopolitics during the Cold War. By continuously showing the flag at the northernmost extremity of the United States during that uncertain period, when any attack on North America would presumably originate from over the Pole, the Lab and Barrow performed a valuable strategic mission in support of the U.S. national interest. What follows are reminiscences, tall tales, some science, and bits of history, all associated with NARL, during a period when the author served in the roles (not necessarily concurrently) of active duty naval officer, research scientist, and assistant program officer of the Arctic Program of the Office of Naval Research in Washington, D.C. How the author arrived at these various positions, and the research on ocean waves beneath the ice pack that he conducted from the facilities of the Arctic Research Laboratory (or simply ARL as it was then known), are discussed. Also briefly mentioned is the intelligence mission, PROJECT COLDFEET, that he instigated and launched from ARL. Publications are cited discussing, in a more august manner, all these various subjects.

Key Words: arctic history; NARL personalities; ARLIS II; NARL air force; Brewer's air force; ocean waves; arctic logistics; Office of Naval Research; PROJECT COLDFEET, drift stations

I first heard of Arctic Drift Stations, and by association, the Arctic Research Laboratory, from my colleagues when I was deep in the shivery bowels of the Antarctic. At that time I was an assistant seismologist for the Byrd Station over-ice traverse program during the International Geophysical Year (IGY) 1957-1959. Our over-ice traverses were conducted only during the austral summers of 1957-58 and 1958-59. They involved bouncing across rough ice for 8-10 hours a day at 3 knots (5 kmh) in cold Tucker Sno-Cat tractors, followed by long hours of arduous physical labour. The thought, therefore, of doing science while drifting along *effortlessly*, or so I imagined, in the Arctic Ocean on drift stations seemed beguiling. In fact, a number of my Antarctic colleagues, or "IGYs" as the civilian scientists called themselves (or "sandcrabs" as the navymen called them), did rotate from their Antarctic tours to such Arctic Drift Stations.

I was just 24 when I left the Antarctic aboard the USS *Wyandot* (AKA92). The ship sailed past numerous tabular icebergs on my way back to civilization. Since these were the days of my adventurous youth, I mused that the tabular bergs would make wonderful platforms from which to conduct oceanographic, meteorological and geophysical research. And what adventure! Just like the Arctic drift stations I had heard so much about at Byrd Station.

Given my choice at that time, I probably would have found a way of proceeding directly from the Antarctic to such adventurous science on top of the world. The 1950s, however, were a time of conscription for healthy young men in the U.S. I had already infuriated my Draft Board (the governmental agency then established to implement conscription) by eluding them. I did so legally, as it turns out, for fourteen months as a result of being sent to the Antarctic by another federal agency, the U.S. National Committee for the IGY. The fact that that agency had written a "please-excuse-Lenny-from-the-Draft (until he returns from the Antarctic)" letter did not sit well with the Board, which was known by the young men in our community as being insensitive, bureaucratic, irascible and vindictive in the extreme. I was never averse to military service, but wanted to serve *when I wanted to do it*. Accordingly, I knew I was destined for military service, one way or another, as soon as I set foot back on U.S. soil.

The U.S. Navy handled all of the logistics while I was on the Antarctic continent. Twelve of the 24 men at Byrd Station were Navy men. After my trip back to New Zealand on the *Wyandot*, I sailed home aboard the USS *Arneb* (AKA56) on a voyage that lasted nearly a month. It was clear to me after this 18-month association with the Navy, that if I were going to serve, it most assuredly was going to be with that service, if I could influence matters. As a civilian scientist living amongst Navy men for more than a year, I had come to learn the Navy's peculiar rituals, and had become comfortable

¹ Topaz Energy Exploration Ltd., PO Box 23087 Connaught Postal Outlet, Calgary, AB T2S 3B1 CANADA

with them. Upon returning to the U.S., I promptly applied for the Navy's Officer Candidate School (OCS) at Newport, R.I. and, in due course, was accepted and legally enlisted, apparently seconds before my Draft Board issued my final draft notice into the Army. Foiled once more by this peripatetic polar explorer, my Draft Board was agitated.

The OCS routine appeared very much the same for me as it was some years earlier for Herman Wouk's Willy Keith of *Caine Mutiny* fame. We emerged similarly, after some misadventures (from the Navy's point of view), as 90-day wonders with a single gold stripe. At a key point during my Navy indoctrination I received a telegram from the Arctic Institute of North America (AINA) asking whether I would be interested and available, to do a tour as a geophysicist on the Air Force Arctic Drift Station, T-3. "Interested," most assuredly I told the AINA from a phone booth, just outside the OCS barracks; "available," ... only if the Institute could pull some strings, for I was a *Navy* man now, and could only do things under proper *Navy* orders.

The AINA had been the contractor for the U.S. National Committee for the IGY, and it was the AINA that paid my salary in the Antarctic. The AINA, I knew, was also a contractor for both the Air Force and the Navy and, in my youthful *naïveté* about such things, I blithely suggested that an arrangement could sensibly be made between both services to have me assigned directly to the Air Force upon my completion of OCS and my commissioning as an officer. Having told them this, I left it in the hands of AINA, and returned from the phone booth to address a more immediate concern, polishing my boots to a high lustre.

The AINA officer to whom I spoke, Bob Mason, broached the subject with Col. Louis DeGoes, USAF at the Air Force Cambridge Research Center (AFCRC) and to Dr. Maxwell E. Britton of the Arctic Program of the Office of Naval Research (ONR). Col. DeGoes said it could work if the Air Force didn't have to pay for me. Max Britton said it sounded like a fine idea to have a Navy presence on an Air Force drift station, and that ONR would pay the expenses, so let's try to do it. He promptly turned this interesting bureaucratic exercise over to that ex-U.S. Marine well familiar with the Navy's arcane procedures, H. Jesse Walker of Colville River Delta fame, who fortuitously happened to be spending a sabbatical year in Max's office just then.

To the surprise of everyone (except me, who knew no better) Jess and Max bludgeoned the request through

the Navy bureaucracy, and the day before I was commissioned and sent to join the icebreaker to which the Navy had assigned me, my orders were changed, and I was directed to spend my first tour in the Navy — with the Air Force, on T-3. So, *that's* how I got to the Arctic.

Shortly before heading north, I met Max and Jess for the first time at ONR. They told me about the overall drift station program, and about the Laboratory at Barrow which was largely funded by ONR. They also told me that *nobody* in Washington had expected my "ridiculous" request to AINA to succeed, least of all, Max and Jess. But then again, they all laughed when I reminded them of boasting that I was going to explore the Antarctic, well before I was accepted for the IGY expedition.

At AFCRC I met with Dr. Albert P. (Bert) Crary (who also had been my Antarctic mentor), and learned about the geophysical research program that I was to continue aboard T-3. Bert had also offered some suggestions about what research I might pursue, and I followed his suggestions. In retrospect, 1959 was a momentous polar year for me: early in that year I left Antarctic glacial ice after a 14-month sojourn there and by November of the same year, I was setting foot on arctic pack ice for a tour lasting all winter.

Shortly after I landed on T-3, I became familiar with camp routine, set up my own research program, and continued programs that had been ongoing. Although I was then the most junior of junior military officers aboard T-3 (or anywhere, for that matter), there was only one other officer there, the base commander, Lt Col. Marshall Hassenmiller, USAF. The remaining personnel were mostly Air Force enlisted men. There were not many scientific personnel aboard for the four months I was at T-3.

It was the best of all possible worlds: I was spared the usual hazing period that enlisted men visit upon newly-minted officers. Fourteen months in the Antarctic had given me credibility in this arctic world with both the enlisted men and the C.O. My officer status, I found, was enormously valuable in the pursuit of my scientific work: no need to beg and cajole the enlisted men, as we had to do as civilians in the Antarctic, for the logistics assistance needed to conduct research. I also enjoyed that special aura, known only to Navy navigators, of knowing how to locate, by celestial navigation, the whereabouts of our drifting station. This, you must remember, was before GPS navigation.

Every other day, in the winter cold and darkness, I would shoot the stars with a theodolite to calculate the station's geographical position. My information guided pilots of aircraft bringing food, mail and replacement personnel. Also from these data I could calculate the azimuth of the rotating ice station by comparing azimuths of the stars with the azimuth of a distant fixed point on T-3. The point I chose, being the romantic that I then was, was the vertical portion of the tail of the DC-3, famed in Arctic lore and photographs of T-3, looking more forlorn by the day as the ablating ice raised this bird higher and higher on its glacial pedestal (Fig. 1).



Fig. 1. The tail of this old bird made a handy reference point, about a quarter-mile away from my theodolite shelter, to compare with the azimuths of stars. Since, at any given time, the azimuth of a specific star is known, it could be compared to the azimuth of the aircraft and the relative rotation of T-3 could be calculated on a daily basis. (Photo by Arnold M. Hanson, courtesy John J. Kelly.)

In this Air Force arctic world, I continually heard stories about the Navy's "Arctic Research Lab." But I was only dimly appreciative, until one winter's day when, with only a few hours of daylight, most of Max Brewer's Air Force—two Cessna 180s—landed on T-3 to refuel. At that time T-3 was north of Barter Island, drifting in a westerly direction. I now realize that the pilots, Bobby Fischer and Bobby Main (both hallowed pilots—God rest their souls) were returning from the evacuation of the crumbling joint Navy-Air force Drift Station *Charlie*. They left their aircraft on the mile-long T-3 ice runway and came to our mess trailer for coffee. I chatted with them there, then returned with them to the ice runway to wave them farewell.

During their short stay on T-3 to refuel and drink coffee, an arctic williwaw came up, in which the wind

shifted 90 degrees from the prevailing direction to which the ice runway was oriented. It was clear to me that they could not take off from the ice runway in such a cross wind. The two Bobbies huddled: they decided to position their Cessnas on one side of the runway, perpendicular to its length, facing into the rising wind. The runway could not have been more than 70 m (230 feet) wide at this point. They set their brakes and revved up the their engines to the maximum their aircraft could tolerate and, in unison, released their brakes. I watched in awe as the two Cessnas roared across the *width* of the runway and were airborne before they could collide with the hummocks and ridges on the other side. This was my *real* introduction to the Arctic Research Laboratory.

During the winter, 1959-1960, I regularly made vertical seismic soundings from the pack ice off T-3 at Colby Bay. I also made frequent measurements with a gravimeter to record not only the gravitational field at any given point in the Arctic Ocean over which we drifted, but to measure the oscillations of this gravity field due to ocean waves and tides beneath the ice. These studies resulted in two papers (LeSchack, 1964; LeSchack and Haubrich, 1964).

In February 1960, a more senior naval officer arrived on T-3. LCDR Beaumont Buck, USN, of ONR came with a crew from the Navy's Underwater Sound Laboratory. They were aboard to conduct an acoustic experiment with USS *SARGO* (SSN 583), which would shortly be cruising beneath the ice in T-3's vicinity. From the Navy's point of view, this was an important experiment since only two years earlier the nuclear submarine, USS *Nautilus* (SSN 571) became the first submarine to traverse the Arctic Ocean beneath the ice. This would be the first time since then, that the Navy would have an opportunity to track acoustically, in real time, a nuclear submarine cruising beneath the ice.

I was quickly pressed into service by Buck as a surveyor to help identify locations for drilling holes in the pack ice for emplacing a circular array of hydrophones. After the array was set in the ice, it was necessary to orient it with respect to true north. This, like orienting T-3 itself, was an exercise in computing the azimuth of the array with respect to a star's azimuth. This needed to be done in the dead of night (not difficult in mid-winter in the high Arctic) with me manning the theodolite in the center of the array and Buck, waving a flashlight, moving from location to location until the azimuth of true north was reached. At one point during this exercise Buck yelled out in terror: "Don't shoot! It's me." It amazed both of us,

how much the sound of thermal cracking of the ice in mid-winter resembles the sound of the bolt action of the M-1 rifles we were ordered to carry to protect ourselves against polar bears.

One night while we were both in the ‘head’ (latrine, for non-Navy types), Buck asked how I got away with growing a beard on T-3 while the other military personnel would, at most, be permitted to grow moustaches. My response was that when anyone commented on my advancing stubble, I observed (correctly at that time) that the Navy always grew beards while on polar duty. And the base commander had the good grace not to press this point with me. Buck promptly began growing his own beard. While I spent relatively little time on the ice after completion of my T-3 tour, ‘Bo’ Buck was to continue his acoustic research in the Arctic Ocean for many years after this, and was a frequent visitor to ARL, which provided much logistic support for him and his research.

Having completed my assignment on T-3 at the end of March 1960, I began my journey back to AFCRC in Bedford, Massachusetts, to reduce the large volume of data I had collected. On the way, I stopped briefly as a matter of courtesy, at the Project *Ice Skate* office (the name the Air Force gave their ice station program) at Ladd Air Force Base (now Fort Wainwright) in Fairbanks, Alaska. This was the office that handled Air Force logistics support for T-3. It was there that I met Captain James F. Smith, USAF, who ran this office and who had earlier been the base commander for Ice Stations *Alpha* and *Charlie*. Although I did not know it at the time, we were destined to play significant roles in each other’s lives in the high Arctic adventure, PROJECT COLDFEET (Leary and LeSchack, 1996), launched two years later from ARL.

I returned to AFCRC for three months to pore through my data to produce reports, and then, in July 1960, I was assigned directly to Max Britton’s office in Washington, D.C. There I assisted him in administering the ONR contract with the Arctic Research Lab, and helped to review unsolicited proposals to conduct arctic research in the physical sciences. It was Max’s office that funded not only the Lab, through a contract with the University of Alaska, but funded numerous principal investigators to conduct their research at the Lab or on the North Slope or out on the ice. Our office at ONR was then responsible for administering the contracts and grants it had let, and to help the Lab and researchers acquire needed equipment, and aircraft and ship support.

After about a year at ONR, I asked Max whether he would authorize orders for me to travel to ARL, and then to the ice, to continue the ocean wave research I had begun on T-3. He thought such a trip would be a good opportunity for me to experience Lab operations firsthand, so he approved, provided, (1) I could scrounge any and all geophysical equipment I needed for my research and (2) I would return to Washington within two weeks of leaving.

I agreed to Max’s conditions, and obtained the equipment I needed to conduct my research project on the ice, a recording gravimeter from the U.S. Navy Hydrographic Office (now the Oceanographic Office), and the microbarograph from AFCRC. What was now needed for my research was a new Navy drift station, for during this equipment-gathering period ARLIS I, my intended base of operations, had broken up and was completely abandoned by 25 March 1961.

I did not have long to wait. Reconnaissance flights from ARL began in early May to find a suitable piece of ice for a new drift station. In anticipation of a station being established momentarily, I made arrangements to leave from Washington, D.C., to Barrow, Alaska, with all my equipment, on 18 May.

Many of my adventures that followed on the newly located ARLIS II are related in the book, *Project Coldfeet* (Leary and LeSchack, 1996). I will relate the story of how I got my equipment to Barrow. The book, aimed at a general audience, omitted this story, but to generations of ARL researchers who have had to hassle, all alone, their equipment to an arctic field site, I expect it will touch a resonant chord. I can almost hear a faint cheer now from some of my old colleagues: that old pushy Navy guy got away with something I’ve always wanted to do!

By this time in my young polar career, I had learned that chances of needed equipment becoming lost, stolen or mis-routed on its way to the Arctic or Antarctic were proportional to the importance of the equipment to the project. I had observed the manner in which the Army Corps of Engineers shipped their equipment to the Antarctic, where there were many transshipment points from original loading to final off-loading and therefore, multiple opportunities for loss of equipment. All their equipment boxes were painted international orange, and members of the crew who would ultimately need the equipment were assigned to watch the unloading and reloading operation at each transshipment point, counting the number of orange boxes at each location. In this fashion, everything was

accounted for all along the way. It is absolutely necessary to do this, because in no way can the shipper, whoever it is, apologize enough or make up for equipment loss that occurs during that small window of opportunity available for conducting long-planned polar operations. If a key piece of equipment goes astray, the operation will be aborted and often, for a variety of irrelevant reasons, will never again be attempted.

Accordingly I, too, painted all eight of my equipment boxes international orange and had the ONR Travel Office pre-arrange, with all the airlines being used to get me and my equipment to Barrow, to agree beforehand, *in writing*, that all equipment would go as *accompanying baggage*. I provided the carriers the dimensions of all boxes and specified that the largest box, the gravimeter, must be shipped in an upright position. All carriers agreed.

Imagine my consternation on 18 May, while watching my orange boxes being loaded aboard the Northwest Airlines 707 at Washington National Airport, when the Northwest loadmaster announced to me that the only way the large box can go is if they turn it on its side so that it will fit in the hold. I pulled out the baggage waybill and showed the loadmaster that Northwest agreed to ship it upright, and suggested that it would fit in the clothes closet in the forward cabin.

A stewardess, recognizing that this disagreement might hinder boarding procedures, now joined in the discussion, announcing it is against company regulations to place baggage of this size in the forward cabin. I reminded the stewardess that the airline had already agreed, in writing, to carry the equipment in question as accompanying baggage and in an upright position. The stewardess then threatened to summon the pilot if I didn't behave. I told her to go get him.

The pilot then entered the passenger cabin and joined in the fray, and by fiat, declared that despite the prearrangement with the airline, they would either put the package in the hold, on its side, or leave it for another, unspecified flight. Unless I immediately agreed, the pilot would call the police.

At this point, in the uniform of an ensign in the Navy, I brought myself to my full six-foot height and told the pilot my orders were "to get the equipment to the ARL at Barrow *now*," and the plane would not leave without the equipment being carried as Northwest had promised. As a military man who knew all about orders, though, I observed to the pilot (rather kindly I thought) that he probably had his own orders too, and he must

do what he must do; but then I alluded darkly that I was a military courier and this was an urgent top security shipment and the Navy and the Department of Defense would not be pleased with the airline's abrogation of its agreement.

The pilot stormed back to his cabin and ten minutes later, instead of the police, the Northwest Airport Manager boarded the plane, took one look at the situation and, most sensibly, ordered the box placed, *upright*, in the forward cabin. Alas, I had more than my allotted 15 minutes of fame, right then and there. Forty-five minutes late, the Northwest 707 took off with an entire cabin load of unhappy passengers casting angry glances at me for being the obvious cause of the delay. The tension was palpable. As sternly and as dispassionately as a Navy ensign can possibly look under the circumstances, I straightened my uniform, made quick eye-contact with all the other passengers, then took my seat. When drink orders were taken I ordered a double martini and downed it quickly, just as James Bond would have done.

This was yet another example for me of the logistics of science moving more smoothly while I was in uniform.

I arrived at Barrow, with all equipment, on 20 May 1961. On 22 May, Max Brewer and the Lab's R4D and two Cessna 180s, flown by the Lab's pilots, Bobby Fischer, Bobby Main and Lloyd Zimmerman, found an ice island at 73°01' N, 156°05' W (Fig. 2). The following day the nucleus of ARLIS II was landed and a camp was set up (Fig. 3). Flying to and from ARLIS II was a unique experience. Flights were made 23 times during the initial phase of establishing the camp (from 24 to 28 May). I accompanied several of these flights to ARLIS II during its establishment and prior to remaining there to set up my own oceanographic research (Figs. 4 and 5).

I flew with "Zim" Zimmerman (Fig. 6) a number of times and we got on well together. From my notes at the time I observed that Zim, an aviator of the "Terry and the Pirates" school, was as colorful as he was good. He had previously flown in Indochina and had a Vietnamese wife. He was now an Arctic roustabout and had flown all manner of winged contrivances throughout the North country and was a student of...well, just people. He knew, it seemed, all the folks from Nome on up around Alaska's North Slope to Canada. Wherever he landed the ARL plane he seemed to find a home.



Fig. 2. ARLIS II from the air in May 1961. The periphery of the ice island can be seen in the photograph. The dark spots are mounds of glacial debris. Photo by Leonard A. LeSchack.



Fig. 3. Building the camp on ARLIS II, May 1961. Photo by Leonard A. LeSchack.



Fig. 4. Bobby Fischer in the cockpit of old 217, preparing to take off for ARLIS II, May 1961. Photo by Leonard A. LeSchack.

Frequently, while roaring over the tundra, 150 m (500 feet) off the deck, Zim passed over a party of hunters looking for caribou or whatever was in season, and they always recognized the colorful lab planes. They always seemed to know when Zim was in the cockpit, for they waved wildly to him.

Heading out to ARLIS II on the logistics support flights from Barrow, Zim would take the R4D up to 100 m (330 feet) or so to clear the ground fog which always hangs around the coast during the summer. Once clear of the coastal fog, he would dive down to



Fig. 5. Bobby Fischer, flying co-pilot, on the way to ARLIS II, May 1961. Photo by Leonard A. LeSchack.

get under the undercast. Then he would follow the radio beacon straight for ARLIS II at 60 m (200 feet) above the ice. This is a strange sensation, roaring along at 120 knots with the vast, unending, ever-changing panorama of pressure ridges and pack ice racing toward you. He would startle a seal, sunning itself on the pack; with one graceful leap, it dove into an open lead and would be gone.

In May 1961, ARLIS II was only a little over a hundred miles (160 km) from Barrow, and within an hour or so Zim would be nearing the camp. On a clear day ARLIS II would loom up ahead quite strikingly; the mountains of glacial debris would contrast greatly with the brilliant white ice, which supported it.

An ice landing is a unique experience; second-hand description will not do it justice. After flying over the



Fig. 6. Lloyd "Zim" Zimmerman in the R4D cockpit, flying to ARLIS II, May 1961. Photo by Leonard A. LeSchack.

pack, which is remarkably smooth flying due to the uniformity of the air over the ice, Zim would prepare for a landing on the unprepared ARLIS II ice strip. It looked about the same as any other part of the ice island, except that it had flags along it to delineate it from the rest of the ice. The camp was at the far end of the flags.

Zim would approach the far end of the strip and throttle down. He would just sail, slowly, gently settling over the runway. The R4D seemed to hang over one spot when coming in for a landing. The only premonition that the landing may be something other than smooth comes from Zim himself. His easy “go-to-Hell” attitude slips away and his jaw tightens a bit and the muscles in his face tense up. The co-pilot starts reading the airspeed indicator. “Hundred... hundred... ninety...eighty-five...[knots].” Full flaps are down. The flags that line the strip are racing past the plane...the ice doesn’t look quite as smooth and homogeneous when one is 10 m above it. Then, after an eternity of gently settling, an almost anticlimactic teeth-rattling, jarring landing. ‘Landing?’ That was a controlled crash!

I liked flying in the Lab’s R4Ds, and I had sense of accomplishment in doing so, since months earlier at ONR I had assisted Max Britton in prying loose those two very R4Ds from the Navy’s aviation bone yard at Litchfield Park, Arizona, and helped invent a reason why “United States Navy” emblazoned on these aircraft should remain, and not be painted over simply because they were destined for a contractor (Fig. 7).

On 30th May Bobby Fischer and Bobby Main flew me and my equipment to ARLIS II in the two Cessna 180s. I remained there until 5 June. In those early days, the station was set up by ARLIS II foreman Kenny Toovak and manned by John Beck, the station leader, Frank Akpik, the mechanic, Charles Edwardson, Jr., the maintenance man (before he went into politics), and Carl Johnston, the cook and baker. Some combination of these gentlemen shot and prepared for dinner a marauding polar bear. Fresh polar bear stew, *au naturel*, (i.e., without seasoning) and *al fresco*, (i.e., without shelter, among the arctic breezes because no dining area had yet been built) was a culinary experience.

During this time I was busy. In a letter to my parents dated 4 June 1961 from “Ice Island ARLIS II, 73°13’ N, 157° 19’ W”, I wrote, in a most artsy green-colored ink:

“Here I am again in my element—the polar

corners of this globe; but not for long. I should be on my way home shortly. But in the short period of time that I have been North I have accomplished quite a lot. I have set up the first scientific measurements on the Navy’s new ice island that was discovered in the Arctic Ocean a few weeks ago. I also was its first surveyor



Fig. 7. U.S. Navy R4D, Bureau Number 17217, on bailment to the Arctic Research Laboratory, wears its official markings proudly as more equipment and supplies, needed to build the camp in May 1961, are unloaded from it. Photo by Leonard A. LeSchack.

and navigator — oh well, all in a day’s work!

Incidentally, I usually don’t indulge in such exotic colours of ink, however, I forgot my Parker 51 blue-black and had to dip into the inkwell of one of my scientific recording machines for this delicious hue (author’s note: we only had analog recorders with cantankerous, leaky pens then)."

I might have forgotten my fountain pen, but I remembered to bring everything else that I needed, a lesson I learned from both Antarctic and T-3 duty: “If you bring it with you, you have it; if you expect the Navy, the Air Force, Max Brewer or John Schindler to provide it to you immediately, when you need it, in all likelihood you won’t have it—in a timely fashion, that is.”

This philosophy was later to serve me well when PROJECT COLDFEET was underway.

Aboard ARLIS II, I had my own tiny short-wave radio. I might have expected there to be a short-wave radio aboard the station. But there was none capable

of receiving accurate time signals essential for calculating positions of the drifting station by celestial navigation, the only way positioning could be done accurately in those days. My short-wave radio saved the day.

William McComas, who arrived at ARLIS II within days of my arrival, helped me set up the equipment to run my oceanographic research program. McComas, a junior scientist, had been sent from the Hydrographic Office to continue taking the readings that I started, because several months of continuous recordings were required. He also was there to look after that office's considerable investment in equipment that ONR and I had borrowed.

We set up an experiment to investigate the directional nature and possible generation mechanisms for ocean waves on the Arctic Ocean. This was an extension of my research, already cited. The waves under consideration have periods between 10 and 100 seconds and amplitudes between 0.001 and 2.0 cm. These waves had been previously observed with gravimeters and seismographs. We set up an array of two continuously recording gravimeters 1240 m apart, one on the glacial ice and the other on the pack off of ARLIS II. The records obtained were examined by cross-spectrum analysis techniques. Waves with distinctly different periods were observed exhibiting dispersion with time, and were associated with a storm over Siberia.

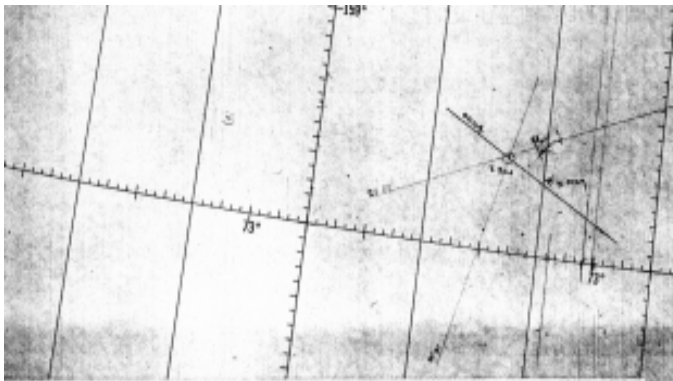
A continuously recording microbarograph sensitive to atmospheric micropressure oscillations in the 10-100-sec period range was also installed at ARLIS II. Distinct oscillations were observed in this period range having amplitudes from 20 to 400 dynes/cm². Power spectra of micropressure records made before, during and after a storm show that the oscillation amplitude is proportional to the period of oscillation and speed of local winds. Cross-correlation between the micropressure records and ocean wave records taken with a gravimeter at the same location as the microbarograph shows a positive correlation between the micropressure waves and the ocean waves. This correlation appears to vary with the direction of the local surface wind and may be related to the orientation of pressure ridges in the ice pack. Although the nature of the micropressure oscillations could not be determined with only the one sensor used, the oscillations were assumed to be progressive waves. These waves contained sufficient force to bend the ice and generate the observed water waves. A detailed account of this can be found in LeSchack (1965).

I returned to Barrow on 5 June after recording the first geographic location of ARLIS II by shooting the sun (Fig. 8), and after making the first map and circumnavigation of the periphery of ARLIS II. I left the following day to return to Washington within the two-week period that Britton had authorized me to be away from the office. Before I left Barrow, however, Brewer came over to me and, chomping hard on the pipe that was part of his persona in those days asked, with a twinkle in his eye, more about that circumnavigation of ARLIS II that McComas and I did. I went through the story again, as recounted in great detail in Leary and LeSchack (1996). He then told me that Kenny Toovak, his ARLIS II foreman, had observed that the M-1 that we always carried to protect against polar bears had been returned to camp, after the circumnavigation, with a barrel packed with snow. "It's a good thing you had no need to fire it," he said, with that look so many of us know so well.

When I met up with Kenny at the NARL 50th reunion, I retold this story to him, but he did not appear to remember the incident. It is not one that a chagrined military man forgets easily. An account of the establishment of ARLIS II was published in LeSchack (1961).

The next time I returned to ARL was a year later, in May 1962. The Navy and the CIA were launching COLDFEET from Barrow. Our attempt a month earlier to launch from the RCAF base at Resolute Bay had been an operational failure, but even though Resolute was closer than Barrow to NP-8, COLDFEET's target, there was not enough time to re-do the diplomatic necessities to launch again from Canada with U.S. military aircraft and still maintain the momentum, now clearly flagging, needed to accomplish our project. Considering the absolute need for support that we found was required from the Naval Air Station Kodiak, and the unquestioning cooperation that we needed, and knew we could expect, from Brewer and Schindler for the entire period we based at ARL, Barrow was now the only feasible choice for launching such an intelligence mission.

I do not remember much about ARL during this trip. The COLDFEET parachute team, Jim Smith, who by then had been promoted to major and myself (I had been promoted to LT. j.g.), were sequestered together in one of the double rooms in the old ARL facility. Although I bumped into ARL researchers who I had known from before, I had little inclination to indulge in the usual ARL camaraderie and the telling of sea stories. I was too consumed with the project, the fear,



This is a photocopy of the actual navigation plotting chart I used in May and June, 1961 to record the positions of ARLIS II at the time it was established. Celestial navigation was the method used for accurate offshore positioning in the Arctic Ocean in those days before satellite-based global positioning systems (GPS). Three lines of position of the sun were measured, using a theodolite, for each of the three days on which recordings were made, i.e., 28 May, 30 May, and 2 June 1961. The intersection of the three lines (for each day) on the chart is an estimate, to within a few miles, of the position of ARLIS II. Only the intersections were drawn for 28 and 30 May, but the complete lines of position were drawn on 2 June. The positions for each of the three days were scribbled on the chart just below this caption.

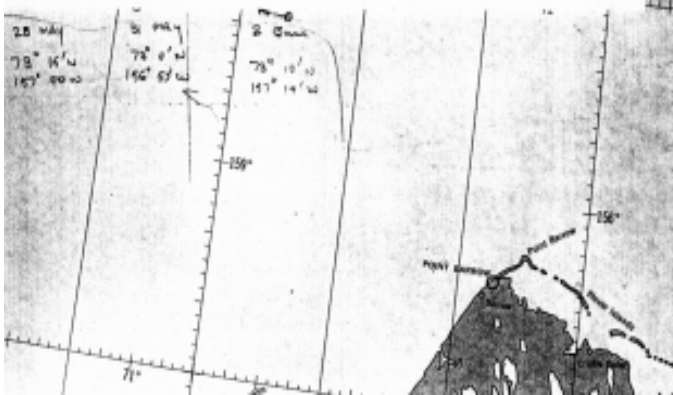


Fig. 8. During the period I was on ARLIS II, I took sun shots to establish the station's location on 28 May, 31 May and 2 June 1961.

the uncertainty, and the knowledge that I had set in motion a potentially life-threatening operation that required many men's time and *matériel* worth millions of taxpayer dollars, to think about anything else. Before we jumped, our schedule was filled with briefings, flying, and sleeping when we returned from fruitless searches in the B-17.

After NP-8 was found, Jim and I parachuted onto the Soviet station and remained there for five days before we were picked up by Bob Fulton's skyhook on the B-17, and brought back to ARL. Upon our return, commemorative photos of our whole exhausted crew were taken in front of our B-17 parked on the ARL airstrip (Fig. 9). Brewer and Schindler then locked off the ARL library and commenced to throw us a superb celebration party, little of which I remember. We spent the following day in the same locked library (Fig. 10),

examining and sorting through the highly classified treasures that we had retrieved from NP-8. Then we returned to Washington, D.C.

I spent the remainder of 1962 in Max Britton's office, mostly involved with presenting the results of our investigation of NP-8 to members of the Washington intelligence community and to interested members of Congress. It was an exciting time, although horrifying for me, because, I got to learn how close we came to a nuclear altercation with the Soviet Union over the missiles stationed in Cuba. Frequently, during this period of recounting our adventures in the Arctic, I was one of several briefers presenting intelligence updates to high-ranking officers. Normally, because all briefers had appropriate security clearances, we remained in the briefing room for the full session. As a result I became immediately aware, from discussions related to these missiles, of the seriousness of this threat, and of how close to war we had come.

At the end of 1962 the Navy assigned me the job as Official U.S. Representative to the 1962-1963 Argentine Antarctic Expedition, and I joined the Argentine icebreaker *San Martin* to sail, once again, to the Antarctic.

I did not return to ARL again until the summer of 1971. At that time, under a research contract from the Defense Advanced Research Projects Agency that was administered by ONR, using a dual-wavelength airborne infrared scanner, I conducted a program to



Fig. 9. The Project COLDFEET crew and CIA B-17 are welcomed back on the morning of 3 June 1962 by our young hosts at ARL, Max Brewer and John Schindler. The two gents kneeling, Major James F. Smith, USAF on the left, and LT(jg) Leonard A. LeSchack, USNR, on the right, were probably drinking beer from Brewer's Tavern, rather than black coffee from the mess hall. Captain John Cadwalader, USNR, COLDFEET'S commanding officer, is in the center of the crowd, wearing the black watch cap. Photo by Robert Zimmer.

measure massive ice in permafrost. A twin-engine Piper Aztec, flown by Alaskan bush pilot Frank Whaley, Jr., carried the IR scanner and landed at the ARL airstrip. We spent several days at the Lab and caught up with some of the researchers I knew from the old days. Although my colleagues and I flew a number of



Fig. 10. Second-Floor ARL Library in Building #250, scene of PROJECT COLDEET celebrations and de-briefings in 1962. Photo by Leonard A. LeSchack.

lines over several known research areas south of Barrow, the bulk of our research was conducted along the then-proposed route for the Trans-Alaskan Pipeline. Our work is discussed in LeSchack et al, (1973).

Although 1971 was the last time that I was at the Lab to conduct research, I did return to the North Slope again in 1982. With the assistance of Beau Buck and the late Dr. Waldo Lyon, then Director of the Arctic Submarine Laboratory, I put together funding from seven international oil companies to fly an airborne laser profiler over the track of a nuclear submarine on patrol in the Arctic Ocean. The point of the experiment was to make a mathematical correlation between the topside roughness of the ice, as measured by the airborne laser, with the under-ice roughness, as measured by an upward-looking acoustic sounder mounted on the submarine.

We leased a specially modified DC-3 (with a third engine in its nose) owned by Beau Buck, and based the operation out of Deadhorse, Alaska. Buck had hired that old ARL pilot, Zim Zimmerman, to fly the plane for us. It was good to fly with Zim again. I hadn't seen him since 1961, and we rehashed old tales, especially the one where he accidentally pumped diesel from ARLIS II into his tanks that resulted in an unscheduled landing on the ice during the return trip. I remembered

that incident well from the Washington point of view. I was still in Max Britton's office when that incident occurred. Max flew directly to Barrow when it happened, and I, then a LT(jg), had to field phone calls from senior Navy bureaucrats wondering what the hell had happened and what was a plane with U.S. Navy markings doing up there anyhow, etc., etc. (Fig. 11).

(In the process of gathering airborne laser data of the sea ice we flew close to NARL, but we didn't land there. Our crew stayed at the NANA Hotel in Deadhorse, where I first met ARL's colorful John ("Jumper") Bitters. Over coffee in the NANA mess hall, as parachutists are wont to do when they get together, Jumper and I began regaling each other with "jump stories," each more outlandish than the last. Just a few months earlier, Britain and Argentina had concluded their unpleasantness in the Falkland Islands. Jumper, an ex-member of Britain's elite SAS Regiment, admitted that he longed to have been there with his old comrades at that time.

While listening to Jumper, I couldn't help wondering whether any of my Argentinian shipmates from the icebreaker *San Martin* had been aboard the Argentine cruiser *General Belgrano* that was sunk in this fracas. Argentina's Navy, especially its officer corps, was not very large. I was a Navy captain in intelligence during this time and attached, as a reserve officer, to the U. S. Forces Caribbean Command in Key West, Florida. I had carefully followed the intelligence and battle reports received by this Command from the Falkland theatre during this period. Fifteen years later, In the conviviality that dominated the 50th Anniversary celebration in the NARL Hotel, my roommate, Captain Brian Shoemaker, USN (ret), a former Director of NARL and Jumper, who had a room a few doors away, revisited this Falkland Island conversation, along with a bottle of scotch.

The results of our laser profiling experiment, based at Deadhorse, to correlate mathematically surface and under-ice roughness was, in my mind, a success on many levels. First, it was unusual for industry to obtain cooperation from one of the most circumspect of military outfits, the Navy's Arctic submariners, in gathering the data set for correlation. Second, the report that I co-authored with Prof. John E. Lewis of McGill University, demonstrated that a robust mathematical correlation was attainable, and could be used for making predictions of under-ice roughness from airborne data. Unfortunately, the offshore Beaufort Sea oil exploration industry that supported the project, collapsed with the fall of oil prices in 1986, a year after

NEW YORK TIMES, FRIDAY, NOVEMBER 17

Plane and 11 Found Safe in Arctic

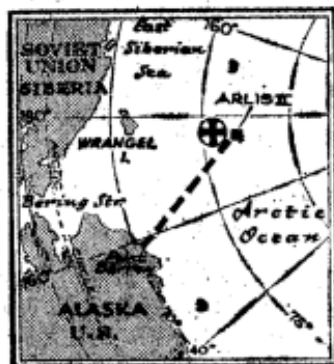
Nov 17/61
A plane that went down with eleven men aboard on drifting ice far out in the Arctic Ocean has been found. All hands are apparently in good health.

The Office of Naval Research in Washington, which confirmed this by telephone last night, said that Max C. Brewer, head of the Navy's Arctic Research Laboratory, was among those on board. The plane was on its way to Point Barrow, Alaska, from that laboratory's drifting station, ARLIS II.

The latter is on an ice island that, in recent months, has been carried onto the Soviet side of the North Pole. The plane went down after covering some thirty miles of its 550-mile return flight to Alaska.

The Air Force, which found the plane, said it was not badly damaged. It is hoped that a rescue attempt can be made during the brief period of daylight today. Because the site is only 800 miles from the North Pole, the perpetual night of winter is almost upon it.

The plane is a Navy adaptation of the DC-3 twin-engine



The New York Times Nov. 17, 1961
U. S. plane found (cross)

Douglas transport. It was apparently being flown by one of the veteran "bush pilots" who have been helping to supply the station under contract. The Arctic Research Laboratory is operated by the University of Alaska under contract with the Office of Naval Research.

The Navy said the plane was fully equipped with survival equipment. Among those on board were several scientists and two Eskimos who had been helping prepare the station for winter.

Fig. 11. New York Times clipping relating the mishap to one R4D returning from ARLIS II in November 1961. (Compare the location in this figure with that for ARLIS II in Fig. 8, determined 5 months earlier.)

our report was written. As a result, there has been no further interest in this work.

In August 1997 I donated to the BASC library a copy of this report, entitled, "Predicting under-ice drafts in the Beaufort and Chukchi Seas from airborne laser profiler data, Alaska Oil and Gas Association Project 283." (LeSchack and Lewis, 1985) The period of confidentiality has expired, and the report may be used and quoted.

As a conclusion to this reminiscence I would like to observe that, over the years, the Navy's Arctic Research Laboratory has had pass its way many individual naval officers, scientists and persons who have administered the Lab's contract from Washington, D.C. It is unlikely, however, that there have been many folks who have viewed, as I have, the Lab in the performance of all three roles. I hope that by sharing some of my memories of the Lab and my activities associated with it I will have added some otherwise unknown bits of history to this commemorative volume.

In historical context, the Navy's Arctic Research Laboratory (NARL) at Barrow, Alaska, has played important roles over the past 50 years, not only by supporting arctic science and assisting in the development of Barrow and Alaska's North Slope, but also in the realm of geopolitics during the Cold War. By continuously showing the flag at the northernmost extremity of the United States during that uncertain period, when any attack on North America would presumably originate from over the Pole, the Lab and Barrow performed a valuable strategic mission in support of the U.S. national interest.

I am pleased that two retired Navy captains, Brian Shoemaker and myself, who have had close ties to the Lab over the years, were invited to participate in the historic 50th Anniversary of the Naval Arctic Research Laboratory, an institution that keeps "Navy" in its name, long after the Navy's departure.

I acknowledge Dr. Max E. Britton who was my mentor in so many ways, some of which have been mentioned here.

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The Arctic Research Laboratory and Institutional Regime Shifts

John J. Burns¹

ABSTRACT: The author recounts a series of unique and varied interactions with NARL, communities on Alaska's North Slope, and various Federal and State agencies over a span of more than three decades. This interpretive chronicle rescues some previously untold events from oblivion, while suggesting the significance of these events within a broader historical context of the Laboratory's evolution.

Key Words: Alaska Department of Fish and Game (ADF&G), Marine Mammal Protection Act, Wainwright, OCSEAP, synthesis meetings, walrus surveys, Western Arctic Caribou Herd (WAH), NSB Department of Wildlife Management, National Petroleum Reserve-Alaska (NPR-A), gray whale rescue

INTRODUCTION

The Arctic Research Laboratory and its subsequent iterations have played a significant role in my arctic exposures for more than 30 years. Looking back over that time I am struck by the intertwined nature and parallels between organizational changes of the "Lab," its missions, survival strategies, and the evolution of my own activities, which were also partially determined by institutional priorities. The "ARL experience" was the sum of several tangible and intangible factors that despite continuity were strongly flavored by the attitudes, responsibilities and personal views of the different Directors toward science and the Barrow community on the one hand, and toward the challenging and eclectic array of itinerant scientists they had to deal with on the other. The Directors, of course, had to function within the mission and constraints imposed by funding sources. They also imposed discretionary limitations on field programs that sometimes seemed capricious to investigators like me. With one notable exception in 1980, however, my experiences at the NARL have been productive, enjoyable, and occasionally hilarious.

My first acquaintance with the Laboratory was while it bore the acronym ARL, and that is still the era I recall most vividly. Yet my connections to the facility over three decades allowed me to experience a remarkable succession of its personalities. Other investigators can claim earlier experiences than mine (Feder, this volume) and others more total time associated with the Laboratory (Albert, this volume, Norton, this volume). Some contributors worked mainly at remote arctic sites with ARL or NARL support (Walker, this volume; Hobbie et al., this volume); others used NARL as

the base for expeditionary forays (LeSchack, this volume). As outlined in Table 1, my experiences included Barrow-based, remote-site, and expeditionary support. This diverse experience has allowed me to perceive four distinct phases in the evolution of the Lab subsequent to its founding, growth and early maturity:

- **Heyday**—institutional maturity and vigor (the last ARL, and early NARL years, 1964-76);
- **Decline**—the reduced support of basic science, and eventual de-commissioning (late NARL years, 1977-80);
- **Reincarnation**—the new-era search for identity and an applied science mission (the early UIC-NARL years, 1981-90);
- **Resurgence**—the current phase in which UIC-NARL once again supports varied research, a healthy share of which responds to local interests and needs (1991-present).

Scientific projects were conducted during each phase, but clearly molded by the continually evolving mission of the facility.

BACKGROUND

In June 1960 I arrived in Fairbanks to undertake graduate studies at the University of Alaska. My field project from then to early 1962 involved a study of the natural history, ecology and management of mink (*Mustela vison ingens*) on the Yukon-Kuskokwim delta, in the southwestern part of the state. The challenges and experiences of that study, during the pre-Prudhoe Bay period of early statehood, provided important practical lessons which instilled a *modus operandi* that stuck with me for 40 years. At that time the local people, having only recently formed consoli-

¹ Living Resources, Inc., P.O. Box 83570, Fairbanks, AK 99708

Table 1. Chronology of John Burns' Interactions with the Laboratory, 1964-1993.

Year	Dates	Base location	Project	Sponsor
1964	5-22 Jul	Wainwright	Seal and walrus harvest sampling	ADF&G
1965	15 Jul-4 Aug	Wainwright	Seal and walrus harvest sampling	ADF&G
1967	6-18 Jul	Wainwright	Seal and walrus harvest sampling	ADF&G
1970	4-19 Jun	Barrow	Aerial survey-coastal ringed seals	ADF&G
1974	10-25 Sep	Barrow	US/USSR coordinated walrus survey	USFWS/ADF&G
	26 Sep-15 Oct	Barrow	Study for PhD exams	ADF&G/personal
1975	6-19 Jun	Barrow	Aerial survey-coastal ringed seals	OCSEAP/ADF&G
	22-31 Jul	Wainwright	Seal and walrus harvest sampling	OCSEAP/ADF&G
	7-11 Sep	Barrow	US/USSR coordinated walrus survey	USFWS/ADF&G
	30 Nov-1 Dec	Barrow	Calibration study, seal morphometrics	OCSEAP/ADF&G
1976	22 Jul-1 Aug	Wainwright	US/USSR marine mammal sampling	ADF&G/USFWS
1977	2-5 Jan	Barrow	Caribou crisis, aerial survey of N. Slope	ADF&G
	6-12 Feb	Barrow	Beaufort Sea synthesis meeting	OCSEAP/ADF&G
	13-18 Jun	Barrow	Aerial survey-coastal ringed seals	OCSEAP/ADF&G
	13-18 Sep	Barrow	Offshore collections of ringed seals	OCSEAP/ADF&G
1978	24 Mar-6 Apr	Barrow/Prudhoe	Offshore collections of ringed seals	OCSEAP/ADF&G
	7-12 Jul	Wainwright	Bearded seal sampling	OCSEAP/ADF&G
	14-16 Jun	Barrow	Offshore collections of ringed seals	OCSEAP/ADF&G
1980	9-20 Sep	Barrow	US/USSR coordinated walrus survey	USFWS/ADF&G
1984	18-21 Sep	Barrow	"Calibration" walrus survey	USFWS/ADF&G
1985	19 Sep-2 Oct	Barrow	US/USSR Coordinated walrus survey	USFWS/ADF&G
1988	21 Mar-10 Apr	NSB villages	Traditional knowledge interviews, fishes	NSB
	25-29 Oct	Barrow	N. Slope Fish workshop	NSB
1989	18-21 Apr	Barrow	N. Slope caribou workshop	NSB
	15-27 Aug	Barrow	Fisheries report	NSB
	2-4 Sep	Barrow to ship	Monitor offshore oil exploration	Shell Exploration
	14-18 Sep	Barrow	Aerial monitoring offshore oil exploration	Shell Exploration
	18-22 Oct	Barrow	Aerial monitoring offshore oil exploration	Shell Exploration
1990	6-10 Sep	Barrow	NPRA studies report	NSB
1991	8-12 Apr	Barrow	N. Slope fisheries enhancement workshop	NSB
	3-7 Jun	Barrow	Workshop report & belukha studies	NSB
	22 Aug-12 Sep	Barrow	Aerial monitoring offshore oil exploration	Shell Exploration
1993	10-14 Jan	Barrow	NSB Scientific Advisory Comm. Meeting	NSB

dated settlements, still lived largely off the land, rivers and lakes. They were intimately aware of their physical environment and the fish, wildlife and other renewable resources to which they were connected. Cash income was meager. Recycling, improvisation, repair and creative scrounging were important activities to master. I studied diligently.

The Arctic Research Laboratory was an interesting abstraction to me during 1960-61. Other students at the University told tales about ice island stations in the Arctic Ocean, field camps on the north side of the Brooks range, studies of tundra lemmings and birds in the Barrow area., and especially about nearly completed studies related to a proposal for "atomic excavation" of a man-made harbor near Point Hope. In most of these accounts, the support hub was invariably the ARL near Point Barrow. The Lab operated satellite facilities on the North Slope, an exceptionally well

equipped main camp, several different kinds of aircraft, and real characters (purportedly) to modify or facilitate progress in science. Occasionally ARL aircraft, especially R4-Ds would show up at the Fairbanks airport. Those exotic airplanes intrigued me in the way that some ocean-going ships still intrigue me at sea or at one or another port-of-call.

In autumn 1961, I was offered a job with the Alaska Department of Fish and Game, as a marine mammals biologist stationed in Nome. At first the work was mainly with walruses (at that time a seriously depleted species) and bearded seals, and the primary locations were the walrus hunting communities of northern Bering Sea and Bering Strait. The start date was March 1962. The months before that had been split between schoolwork, trying to learn about the region and people with whom I would be involved, and earning a minimal income. Dr. Otto Geist, an archaeologist,

provided work processing some of his incredible collection of Pleistocene mammal fossils. More importantly, he and Dr. Ivar Skarland, an anthropologist, spent many hours sharing their knowledge about the cultures and economies of the northern Bering and Chukchi sea peoples. Geist had recently wintered in Barrow and acquired a substantial collection of frozen specimens, including fetuses of all stages, from ringed seals (*Pusa hispida*). That collection, turned over to others at the University of Alaska, was inadvertently destroyed by a malfunction of the large walk-in freezer in which it was housed. For a variety of reasons, such a collection from northern Alaska will probably never be duplicated. In any case, Geist became a role model – he enjoyed good beer, knew the northern Bering and Chukchi sea coasts and the indigenous peoples, enthusiastically shared his insights and knowledge, was an inveterate collector of all manner of “stuff,” and he was a world class scrounger of things useful in the field. We talked often and at length about St. Lawrence Island, occasionally about the principal hunters at Barrow, but rarely about the ARL. Dr. Geist preferred living in the community of Barrow, rather than “way out at that Navy Station” where he felt cut off from many of the active subsistence hunters. I came to learn that even in the 1960s, years after Geist had finished his fieldwork on St. Lawrence Island, the elders there still spoke highly of him.

Dr. Laurence Irving who later served as Chairman of my Ph.D. graduate committee, guided my future toward involvement with the Arctic Research Laboratory, by suggesting in 1963 that when my studies of walrus and seals eventually began to have a more northern summer-season focus, it would be time to work at one of the hunting communities along Alaska’s northwestern coast. Dr. Irving made it clear that success of such a plan would hinge on securing the next thing to a Papal Blessing: a successful audience with, and the consent of, Dr. Max Brewer, the then-reigning enlightened dictator at the ARL. Irving also noted in passing, that if I were fortunate enough to be at the Lab during the time of an official inspection or visit by dignitaries, the food would undoubtedly be very good and the “house whiskey” would, like as not, be fine quality Scotch. Eventually, after his coaching, further information gathering and the non-random selection of dates on which to transit through the Lab facilities, Dr. Irving’s insights and understanding of such matters were confirmed.

The spring-early summer of 1964 was my third field season at King and Little Diomed islands in the Bering Strait. These were demanding but rewarding locations

for biological studies. Almost the entire population of Pacific walruses and a majority of the bearded seals migrate northward through the strait in April-June. Access to specimens and data was good, despite the fact that large seals and walruses were butchered at kill sites away from the islands, which limited opportunity to carry out detailed necropsies to a few animals each season. The people were kind and cooperative, even after I imposed the first bag limit on the number of female walruses they could take. Logistics, however, were difficult and there was no privacy with respect to lodging or the ever-present need to preserve and store specimens or maintain records and other types of paperwork. Large items had to be sent to the islands in October, aboard a government supply ship (the *North Star*) that stopped by once a year. In winter, at Little Diomed, a small landing field for ski-equipped bush planes was laid out on sea ice that formed between Big and Little Diomed islands. “Safe” conditions usually developed by mid-January and lasted until the landing field broke up and drifted north in mid-May. Travel to the mainland during the open water season was by skinboat. I would go to the island in late April or early May, by plane, and return to the mainland, via *Umiak*, when Bering Strait became mostly ice-free, usually in late June-early July.

Timing of the walrus and seal migrations was such that it was desirable to continue obtaining samples later in the summer, in a different part of their annual range, by working with hunters at more northerly communities. I was thus moving toward acting on Dr. Irving’s advice.

TO THE ARCTIC

In the summer of 1964 I went from Bering Strait to Barrow. My plan was to sample marine mammals taken by hunters from Barrow, using the ARL facilities for room, board, lab space and local transportation. Barrow proved to be an inconvenient location to sample the large pinnipeds. The road between ARL and Barrow was in bad condition during that summer. Barrow was also a spread-out community, and the hunting boats landed along several miles of beach. Most of the hunters did not want to be delayed by someone wanting to cut into and examine their catch. As a government-employed biologist myself, I was particularly aware that many of the active hunters were still upset by their eider duck run-in with the U.S. Fish and Wildlife Service enforcement agents in 1960 (O’Neill 1994:232). Major revision to my plans was called for by this array of handicaps at Barrow. Mutual understanding would obviously have to be cultivated the way Dr. Geist had cultivated it, by spending a lot of

time in the community. The busy days of waning summer in 1964 were hardly the time to begin that process. I was fortunate, nevertheless, to meet two outstanding hunting captains: Mr. Harry Brower Sr. and Mr. William Kaleak. Both of them are honored today for their many years of contributions to a broad understanding of traditional and non-traditional arctic science. To me they were notable for their interest, advice and cooperation. Just as I was concluding that my work at Barrow had reached an impasse, they confirmed my hunch that Wainwright, a smaller community located some 120 km (70 miles) down the coast, would be a better place to conduct my work.

I met with Max Brewer, told him of my intention to go to Wainwright, and requested use of the ARL wannigan in the village. After a brief discussion of my studies I mentioned that I needed use of a vehicle to drive to Barrow to buy food and arrange for an aircraft charter. He said that neither request was necessary. Rather, I should give him a list of what I needed, and tell him when I wanted to go. Things were beginning to look more promising.

FOND MEMORIES OF WAINWRIGHT

On 5 August I departed the ARL in one of the Lab's float-equipped small planes, loaded with more food and other supplies than I would ever have had the courage to request. We landed in the Kuk River, some distance from the village. The short airstrip near the village was a muddy quagmire, unsuitable for wheel-equipped planes until it dried up. I had made no prior arrangements with the residents. When the plane departed I had a pile of stuff on the river bank, including a large tank of propane for heating the wannigan and cooking. After carrying my personal items to the village and locating my temporary home, I received a visitor (Homer Bodfish). In a friendly, but investigative manner, Mr. Bodfish inquired about my intentions, the proposed duration of my stay, and other people I knew who had done research in Wainwright. At that time I casually knew Dr. Fredrick Milan, a physical anthropologist in Fairbanks, who had completed a study of human adaptations to cold weather conditions that involved several years of work with the people of Wainwright. Milan was obviously a very important person to know because the mention of his name, almost by accident, immediately resulted in a reserved welcome. Also, the fact that I had been "delivered" by ARL, and had permission to use their cabin, indicated that I had passed muster with Brewer (the 'Papal Blessing'). One's acquaintances were important details. Someone suggested that I check with Mr. Raymond Aguvaluk, manager of the small village

cooperative store. He might help arrange to have my gear hauled by tractor and sled, to the village. Raymond and I retrieved the large pile of equipment and supplies. He and his wife Lizzie became valued friends and important facilitators of my work in Wainwright.

Journal notes for 6 August indicate my good fortune:

"Things could not look more promising for detailed work on bearded seals and walruses. Hunting activity is at a peak. Many are being taken. They are brought ashore whole along a narrow stretch of beach immediately in front of the village and moved around with the John Deere tractor. There are quite a few in the village that are yet to be butchered. The ARL wannigan I have to live and work in is like a palace compared to the facilities on Little Diomed Island."

Later journal entries remind me that in summer 1964 there were 282 people and 540 sled dogs in Wainwright. The summer hunting was done mainly with skin boats unless the sea ice moved too far from shore. Much of the walrus meat was used to feed the sled dogs. All meat not immediately consumed or dried was stored in large ice cellars dug into the permafrost. The little tractor with its front-end lift was ideal for weighing even the largest bearded seals, but could handle only small walruses (Fig. 1). Raymond Aguvaluk devoted a lot of his time to running the tractor and lifting the animals for me. The hunters, and more importantly their wives (they were responsible for the care of the seals) were interested in my studies and were helpful in approving of my collection of specimens.

The pace and timing of daily activities at Wainwright were convenient and productive. Weather and proximity of the drifting sea ice regulated opportunity and success during the important summer hunting period, when most walruses and bearded seals were taken. Daylight, of course, was continuous. Favorable conditions usually existed for only a short time (1-3 weeks) and bad weather could intrude on this short window to reduce the number of days on which the boats go out. Hunting crews as a rule would depart during early to mid-afternoon and remain out until early morning, sometimes making two trips if the ice were close and the hunting productive. The animals were towed to the beach and left there, or moved close to the home of the appropriate hunter, for butchering later in the day. In general, women processed the seals and the men did the walruses. As the boats returned I numbered and measured the animals as they were landed. Later in the



Fig. 1. Light-duty John Deere tractor, used initially to weigh all bearded seals and small walruses brought ashore at Wainwright, 1964. Photo, John J. Burns.

day, as folks began to stir again (late morning), Raymond Aguvaluk and I, using the tractor, would weigh the bearded seals and small walruses before the butchering started. Later still, usually when the hunters went out again, I obtained specimens from the previously numbered animals, including walruses that were too big to weigh. If animals were being taken steadily during prolonged good weather, it was necessary for villagers to stop hunting after 2-3 days, to process and store all of the landed meat. That sort of cessation, along with Sundays (no hunting) and the occasional bad weather day, permitted all of us to catch up on things, including rest. Summer hunting of marine mammals ended either when a sufficient amount of meat and hides (primarily for skin boats) had been secured (as in 1964 and 1965) or when the ice and associated game moved too far offshore. After that, the people switched their focus to resources of the land and rivers, and began getting their annual supply of caribou, fish and berries.

All of us accommodated to one another's needs. The Wainwright people were intensely curious about my field collections. They pored over stomach contents to see what odd food items were present (being already knowledgeable about the common ones). They examined placental scars, embryos and small newly implanted fetuses, biological signs of population health not previously obvious to them. Parasites were not a particular hit. As the days passed, I accumulated a following of boys too young to accompany the hunters who worked like little demons locating tagged seals

that had been moved from the beach, hauling buckets of tools and specimens, and generally being helpful (Fig. 2).



Fig. 2. Young and eager helpers in studies of walrus harvest at Wainwright. Photo, John J. Burns.

After initial reluctance on the part of the women, and at first under their close scrutiny, I was permitted, and finally encouraged to butcher seals when many were coming ashore. My three seasons in Bering Strait working with hunting crews that were often racing against potentially crushing movement of the pack ice, had honed my butchering skills. At first, my community acceptance accelerated the whole butchering process. I could begin obtaining my samples early in the morning before most folks were up, start on the day's landings, sample more animals in a day, and help community members when they showed up. But soon the Wainwright women noticed that if they waited long enough, the eager biologist and his group of little helpers would eventually do their cutting for them. Things slowed down again, and I became busier than ever.

Wainwright's harvest studies differed from those at Little Diomed and King Island. The biologist had to remain onshore, while hunters were out, to be ready to process the animals brought in by small crews that returned at different times. Bering Strait villages tended to send out only two or three large hunting crews, and they tended to work together, departing and returning within a short time of each other. My focus there was primarily on walruses, which were butchered at the kill sites. Usually I went with them and obtained the desired specimens, but the trips provided little opportunity to observe animals in undisturbed conditions. Wainwright, by contrast, offered outstanding opportunities to observe the migrating marine mammals. On

the “leisure” days, especially when the ice was close, someone would usually go out solely for the purpose of watching and photographing marine mammals, and after a while I was invited along. Such opportunities increased in subsequent years.

The 1964 summer field season at Wainwright was indeed memorable and productive. That success was due in part to the initial opportunity provided by Max Brewer and the ARL, and established a routine that was repeated 5 more times between 1965 and 1977. Every subsequent season in Wainwright also produced interesting recollections. After 1964 I always brought a field assistant as the array of opportunities for various kinds of biological sampling was large.

Two notable events highlighted our second season (1965) in Wainwright. First, my assistant, upon lighting the propane oven for the first time, blew the windows out of the wannigan. Fortunately he was uninjured except for the loss of his beard. Second, and more importantly, the annual supply barge arrived in mid-July carrying a magnificent Caterpillar crane. I saw at once how this piece of equipment could be put to scientific use at Wainwright. The loadmaster, who was conveniently unsure of the intended destination for the crane, was soon amiably persuaded to offload it at Wainwright. With that “cherry-picker,” operated by David Bodfish and Billy Patkotak, we were able to process even the largest of male walrus (Fig. 3). People promptly developed a keen interest in learning the weight of the heaviest walrus taken by a crew, and by extension, who would catch the biggest one of the season. Previously there had been no weighing devices with which to stimulate competition or the friendly wagering that may have ensued. Thanks in part to this keen interest, a number of large walrus yielded body mass data for our biological analyses of age and growth. As I recall, the crane stayed in Wainwright for only two summers before it was sent onward. I never did learn where the crane was originally supposed to go (or who would cheerfully have wrung my neck for delaying its delivery).

A decade later, in the 1975 season, ice conditions were severe along the entire northern coast of Alaska. The fleet of tugboats and barges bound for Prudhoe Bay was largely unable to reach its destination, most getting only as far north as Wainwright. After waiting for more than a month, most of that fleet returned south, still fully loaded. Hunting success for walrus and bearded seals was unusually poor as the *umiaks* had great difficulty penetrating the heavy, closely packed ice. We changed our focus to more intensive



Fig. 3. Large male walrus being weighed with ‘cherry-picker’ at Wainwright, late 1965. Photo, John J. Burns.

study of ringed seals, which were taken as an available alternative to walrus and bearded seals.

REGIME SHIFTS AND MARINE MAMMAL RESEARCH

By 1972 Cold War relations between the U.S.A. and the U.S.S.R. were beginning to thaw, at least in the arena of marine mammal research. Scientists were permitted to work together, on a “receiving-side-pays” basis. This thaw was a major opportunity for my close colleague, the late Dr. Francis H. Fay (U. of Alaska) and me. We had long hoped for the opportunity to exchange more than letters and published papers with Russian counterparts studying the same general questions about shared resources, but isolated from us by the “ice” curtain. NARL facilitated some of the earliest visits by Russian marine mammal specialists. American scientists boarded Soviet research vessels at anchor off the NARL, for extended research cruises in the Chukchi Sea. In 1976 my field associates at Wainwright were two scientists from the marine mammal laboratory in the Soviet Far East. Subsequently there were many other exchanges that did not depend on NARL facilitation.

Federal legislation and changed jurisdictional responsibilities greatly altered the structure of Alaska’s marine mammal programs in the 1970s. In 1972 the Marine Mammal Protection Act was passed. One result of that law was to shift jurisdictional authority for management of all those animals from the coastal states in whose waters they were present, to the federal

government. The Act did include provisions for return of authority to a state, if specified criteria were met. After a large investment of time, person-power and money, with only limited success, the State of Alaska finally stopped trying. None of the other coastal states pursued such an attempt. By 1975 direct funding for marine mammal research by the State was at a low point. At this low point, however, a massive multi-year marine research initiative entered the picture. That regime shift was the Outer Continental Shelf Environmental Assessment Program (OCSEAP), funded initially through the National Oceanic and Atmospheric Administration.

In the early 1970s international events had precipitated a fossil fuel crisis, in response to which the United States embarked on a program aimed at achieving national energy “independence” (Norton and Weller, this volume) or the Nixon Administration’s term for “self-sufficiency.” The Outer Continental Shelf of the entire country was initially considered for rapid leasing to permit companies to explore vast acreage at unprecedented rates for offshore gas and oil deposits. Alaska, with its majority (some 70 percent) of the nation’s continental shelf, held the best hand of cards and received a large share of the attention and funds over many years. Environmental assessment was required to accumulate information necessary to prepare the required pre-lease environmental impact statements, as well as for many other regulatory purposes.

A key component of the OCSEAP became studies of marine mammals. That program breathed new life into the moribund State research program, of which I was the Coordinator. Our focus changed overnight from management-driven studies of harvested resources, primarily in the coastal zone, to broader ecological research in both coastal and offshore waters. The logistics support available to OCSEAP researchers was varied and outstanding (NOAA research vessels, small water craft, fixed-wing and rotor aircraft and surface vehicles down to snowmachines). Since the Chukchi and Beaufort seas generated the petroleum industry’s greatest interest, fired in large part by earlier discoveries of oil at Prudhoe Bay, NARL itself experienced a reprieve from desertion by the Navy (Kelley and Brower, this volume). NARL continued to be pivotal in the support of many OCSEAP-funded programs including those on marine mammals.

Marine mammal studies conducted out of Barrow involved nine different field efforts, in all seasons of the years, 1975-1978. These studies ranged in scope from the standardization of necropsy and sampling proce-

dures using seals obtained by the Lab to feed their resident polar bear (“Irish”) and other animals, to various offshore collections of ringed seals, to coast-wide aerial and ground-based seal surveys, using specially trained dogs. NARL itself hosted the best organized and most productive inter-disciplinary “synthesis meeting” in which I have yet participated (Weller et al., 1977). That meeting served as my model for subsequent meetings whenever I bore some responsibility for their planning and execution.

POLAR BEAR INCIDENTS

Several incidents punctuate my memories of the OCSEAP period. One was a very close encounter between Dr. Thomas Albert and a polar bear, within the fenced confines of the Lab’s Animal Research Facility (the ARF). We had saved the carcasses from an offshore collection of ringed seals and, unwittingly, created a bait station. The seals were saved for use as traditional food in meals provided to the elders in Barrow. They were temporarily stored frozen, on the ground, between the rear door of the main ARF building and three artificial hibernacula in which Dr. Albert held arctic marmots (*Marmota broweri*), for his study of the physiology of hibernation. A polar bear had entered the compound through an open gate and, undetected, was feeding on the seals. One dark and stormy evening, Dr. Albert was going to collect telemetry data from his marmots when, in his words:

“After nearly knocking my head off, the bear chased me back toward the main ARF building. I was running as fast as I could! When I first glanced over my shoulder the bear was right behind me. About three-fourths of the way up the door ramp I noticed that the bear had stopped chasing me and was going back to the carcasses. I went through the ARF, out the front door, and closed the gate of the chain-link fence on leaving the compound.”

Having narrowly escaped incorporation into the arctic food web, Dr. Albert then called his wife and children and asked them to come to the ARF, and to bring a camera. Eventually the bear was tranquilized, trucked to the north end of the NARL airstrip, and released.

Other incidents also involved polar bears. During late March 1978, on ice offshore of the Colville River delta, we saw from our helicopter the fresh tracks of a sow with two small cubs, leading away from the land. We decided to try to locate the natal den from which the bears had recently departed. More sets of bear tracks were evident the closer we got to the mainland coast. After some 10 minutes of acrobatic low-level flying, we located and landed alongside a single exit

Another Athletic Escape at the ARF

One of my fellow graduate students in Fairbanks came in 1971 to visit my research sites, experience the Barrow environment, and to walk tundra hallowed by Frank Pitelka and his students near NARL. Paul Whitney came for a 3-day visit, toting his trademark, an 8-mm windup movie camera (technological grandparent to today's camcorder). Among the things he wanted to film, two orphaned polar bear cubs, being held that summer in a sort of high-security nursery at the Animal Research Facility (ARF) topped his list. Despite his keenness, I contrived to put off Paul's filming project until he had only 30 minutes to spare before his return flight to Fairbanks.

As luck would have it, the 30 minutes into which I had procrastinated fell during lunch hour, such that no experienced animal caretakers were on duty at the ARF. My dread of the bear-filming venture increased by about a thousand-fold upon realizing that our rescuers would be relaxing a block away, at the Camp Dining Hall. I had watched Don Sanders roughhousing with those cubs when they were smaller. But I had also observed Don's face and hands register his daily tussles with the fast-growing youngsters: throughout that summer Don looked like the perpetually recovering victim of vicious muggers. Don's recipe supposedly to keep the cubs from intimidating him, was to push the door to their cell inward hard and fast enough to knock them sprawling. Otherwise, the instant their foreclaws appeared around the edge of the inward-opening door to draw a playmate into range of their claws and teeth, the cubs would have all the initiative on their side.

These considerations led me to discourage Paul's interest in filming the cubs; I explained my reluctance in the most persuasive terms I could muster. Paul's

determination nevertheless won out over my caution, so that he soon had me leading him to the ARF. My foreboding increased another thousand-fold when we found our way to the cubs' cell door blocked by a waist-high steel tank containing salt water and a frightened juvenile ringed seal. It took a minute for the two of us to wriggle through the slit between the corridor wall and the massive tank while its occupant splashed nervously. At last we were hemmed in and braced in crouching positions before the cubs' cell door. A whispered final check confirmed that Paul had wound and aimed his camera to get brief images of cubs' forepaws on film. (I had zero motive to go inside, for playful dismemberment by a pair of 30-kg mauling machines).

What happened next could not have taken two seconds. I turned the doorknob, opened the door a crack, glimpsed four whitish forepaws curling around the door toward me, hurled myself at the door with all my strength against the inmates' bodies, and re-slammed their cell door. Instantly I turned in relief, to confirm that Paul had got a few frames of the action. Having magically evaporated from the space between the tank and me, Paul was a shrinking human torso surrounded by a blur of arms and legs, visible through the ARF front door, and already far down the road toward the Chukchi Sea shoreline.

In the decades since, neither of us has explained the physics behind the trajectory of Paul's combined broad-and-high-jump from a crouch, which catapulted him over the seal tank. Nor have we seen any Olympic sprinter match the burst of speed that put so much distance between Paul and the ARF by the time I retrieved him to catch his flight to Fairbanks.

Dave Norton

hole in the top of a den in deep snow along the west bank of the Colville River delta. There were numerous fresh tracks around and near the opening. I was reasonably sure (but not positive) that the den had been vacated. We listened intently for animal sounds from the den, but the only noise was the wind. Finally I decided it was safe to enter the den to measure and photograph it. I squeezed down into the hole to about the level of my armpits. My feet had not yet touched the bottom, when from a few paces behind me, my assistant—perhaps still queasy from the violent helicopter ride—was seized by a fit of coughing. At this unex-

pected noise I reflexively shot out of the hole, rolled down the snowbank, curled up to protect my head, and braced for an imminent bear attack. When nothing happened, I glanced around to find the pilot and my assistant peering down apprehensively, as if wondering what possessed me. As soon as our courage returned, the three of us explored the elaborate, 2-chambered natal den. On a less eventful occasion we saw a large bear stick its head out of another den as we landed nearby. It stayed inside and we promptly departed. A bear was around that den each time we passed it, for about a week.

US-SOVIET WALRUS SURVEYS

NARL was also pivotal to a series of coordinated American-Soviet aerial surveys of the Pacific walrus population. Aircraft from both countries conducted surveys to the limits of their respective 200-mile economic zones, at roughly the same time in autumn. The ultimate objective was to conduct a joint survey every 5 years, for the purpose of determining size and trend of the population. The American surveys in the Chukchi and Beaufort seas that I participated in were made between 1974 and 1985. I also flew on a Russian survey in 1989. Calibration surveys, to familiarize personnel with conditions, procedures and protocols, were conducted in 1974 and 1984, and the full-scale coordinated surveys occurred in 1975, 1980 and 1985. Several earlier U.S. walrus surveys (before 1974) had all been in the Bering Sea during early spring, and were uncoordinated with Russian surveys. In the Bering Sea the winter distribution of walruses covers a huge area, so the sampling intensity was comparatively low. We thought that by switching to the early autumn, when the sea ice cover is minimal and the walruses more concentrated, a bi-national effort could achieve more effective and efficient coordinated surveys.

Although I participated in almost all of the surveys from the early 1960s onward, I was always uneasy about them for a variety of reasons. Even minor mechanical problems with the aircraft were worrisome because we operated so far from shore. In the Bering Sea we were repeatedly intercepted and sometimes harassed by either Soviet or American warplanes (Fig. 4), even though we always painstakingly informed both governments about the details of each survey in advance. We only had one such incident in the Chukchi Sea, west of Cape Lisburne.

Autumn surveys posed unique challenges, both mechanical and weather-related. In 1974 we used a Grumman Mallard, which turned out to be unsuitable for the icing conditions we encountered. The first incident with that plane was the loss of an engine during a pre-flight engine run-up on the NARL ramp (better there than elsewhere). That loss pushed the survey later into the autumn. The recurring problem of icing, due in part to design of the aircraft, caused us difficulty and constant anxiety. The plane was lost during a seabird survey in the Gulf of Alaska within weeks of our completing the walrus survey. Two of our newly trained observers thereupon decided that walrus surveys were a more hazardous line of work than suited them. I remained at NARL for several weeks after that survey, as it was the ideal place to complete the review



Fig. 4. Soviet MIG warplane, alongside, and viewed through the window of a U.S. civilian DC-3 during a U.S. walrus survey over the Gulf of Anadyr, just outside the USSR's 12-mile limit, May 1968. Photo, John J. Burns.

and study required for my upcoming exams at the University.

Anxieties aside, the walrus surveys of 1975, 1984 and 1985 involved “manageable” kinds of problems and achieved their objectives. There were only two minor incidents, both in 1985, when two planes were used simultaneously. On one an alternator failed and on the other the forward landing gear collapsed upon landing in drifting snow conditions.

OFF-SETTING NAVAL ENGAGEMENTS

The exceptional survey, both unmanageable and “memorable” for the wrong reasons, was the one conducted in 1980. During the September, 1980, survey the Navy's retreat from NARL was in progress. The hangar at the airfield was entirely functional (heated and lighted) but designated as “secured.” The base commander was a Navy officer, and Dr. John Kelley (U. of Alaska) was the resident Director for Science. We were staying at the Lab and operating off the NARL airfield. It should be noted that the survey effort was a federally funded project, paid for by the U.S. Fish and Wildlife Service. Our airplane was a Cessna Conquest that was on a scheduled progressive maintenance program. Inspections and replacement of parts were based on hours flown rather than on waiting for problems to develop. It was an efficient system. We flew the plane during the day, and the maintenance was done at night, outside on the ramp. On one particular evening the mechanic was faced with a time-consuming and difficult part change. It was dark and the weather was cold, windy and snowy. We tried to erect a windbreak from available materials but it provided the mechanic

too little protection from the swirling snow and cold. All of the lights were on inside the warm and empty hangar. I told the mechanic that I would see what could be done to gain entry to it.

My inquiries confirmed that the hangar had been “secured” which, in Navy parlance meant that it was off limits, regardless of our mission or problems. It was none of my business that it was empty, though still heated and lit. Where was someone with the accommodating attitude of Max Brewer when he or she was needed? Later that evening a long-term acquaintance (who shall remain nameless), after listening to my problem, said that indeed all the doors were dutifully locked, but the casing on the small side door was only loosely secured to the building’s frame. The main hangar doors were simply latched from the inside. Everything would probably be fine if our airplane went in and out of the hangar before dawn. From my perspective, and considering different mitigating factors, there was only one logical course of action.

The plane went into the hangar. The mechanic completed his tasks. The night watchman, however, discovered the infraction, reported it to the base commander, and all hell ensued. I was told to terminate the mission immediately and to consider myself under house detention. After a few hours (I think Dr. Kelley interceded on our behalf) it was decided that: 1) we could continue the mission, which would speed up our departure, 2) another designated person could remain ashore as the surrogate detainee (the statistician volunteered) and 3) I would have to answer to the proper authorities at a later date.

Fate works in interesting ways. Weather conditions were excellent and the first flight of the next day proceeded normally. While *en route* back to Barrow to refuel, we noticed a target on the radar which I assumed to be a field of detached ice about 20 km south of the pack ice margin. Large numbers of walruses often haul out on floes in such detached fields of ice, so we flew to the radar target but, instead of a floe, found two large Soviet surface vessels seemingly drifting, while a third vessel approached at high speed. We photographed them, noted their positions and proceeded to Barrow. On the outbound leg of our second flight of the day we again passed over the ships. This time there were four vessels, one of which was a disabled nuclear submarine, on the surface (this was all happening within the U.S. economic zone, about 140 km, or 80 miles west of Barrow) and being administered to by the 3 surface vessels: an icebreaker a submarine tender and a large tugboat-like ship. We

made low-level passes and took many photographs before resuming the walrus survey. There must have been something seriously wrong aboard the sub for it to surface after we Americans in an airplane had discovered the eventual rendezvous point.

That evening I telephoned our sighting to the officer on duty at the Adak Navy Base and was told that they would dispatch a plane to check things out. Before hanging up I “casually” suggested that in light of our “unusual contribution to the national security,” the duty officer might be able to ease the pressure a bit on our misdeeds at the NARL (any port in a storm!). I never found out whether Adak folks actually interceded to alleviate my problem.

Our walrus survey grid was completed without further incident, but under considerably strained relations at the NARL. Upon my return to Fairbanks I was contacted by an FBI agent and subsequently by the Federal prosecuting attorney. I was asked to surrender the photos of the Soviet vessels, before they were developed, but I respectfully declined to do so at that time. Things looked serious for a while: I was threatened with a battery of federal charges. The FBI agent was more sympathetic than the attorney. After several weeks of “communicating” it was decided that the various charges would be dropped if I gave them the undeveloped film. I did so with the understanding that I was to receive copies of the pictures. I received some photos several months after this deal was made (Fig. 5). Otherwise, the matter was apparently dropped. That ordeal, during the Navy’s last days at NARL, was the low point of my various northern exposures.

CARIBOU AND POLITICS

Another of my memorable arctic adventures coincided with OCSEAP, but was unrelated to offshore bioenvironmental studies. On 2nd January 1977 I flew from Fairbanks to Barrow to deal with a crisis that involved the always volatile mix of politics and caribou management. At that time I was Regional Supervisor for the Interior and Arctic Region of the ADF&G. Two enforcement officers from the Alaska Department of Public Safety, Officer Richard Hemmen and Lt. William Valentine, accompanied me. The NARL was again central to events that transpired.

This incident is of historical interest, particularly for its contrast with the impasse between North Slope whalers, and the International Whaling Commission’s attempts to restrict subsistence take of the bowhead whale (Albert, this volume). The Western Arctic Caribou Herd (WAH) occupies a potentially vast annual

range that expands and contracts in relation to size of the herd. With caribou, extreme population fluctuations, although infrequent, do occur periodically. An extensive aerial-photographic survey in 1970 resulted in a population estimate of more than 240 000 animals. Annual harvests during the late 1960s were on the order of 25 000. WAH animals were taken by hunters from as many as 28 settlements along the herd's seasonal migration routes. Clearly this caribou herd was an important source of food and byproducts to many Alaskans. A major decline in this herd occurred between 1970 and 1975, when the next large-scale census estimated WAH numbers at 75 000. This decline was accompanied by a great retraction of the herd's annual range, and failure of the caribou to migrate near many of the villages. In 1976 ADF&G restricted seasons and bag limits to reverse the precipitous decline, and to allow the herd to recover. The restrictions, though unpopular, were generally complied with (many villages simply had no caribou to hunt). The great reductions in harvests, particularly at the caribou-dependent communities (of which Anaktuvuk Pass is the most dependent) were to be offset by various assistance programs administered by other branches of the State government.

By late 1976 (still pre-oil-wealth times) local leaders viewed the promised assistance to villages as too little and too late. Mr. Eben Hopson, a statesman and political leader whom I greatly admired, was then Mayor of the North Slope Borough. He was determined to force the issue and obtain assistance for residents of villages within the Borough. The State Legislature was scheduled to convene its annual session in early January 1977. Timing was critical for obtaining approval by that body, and executing subsequent relief actions by appropriate State agencies.

In December 1976 the NSB decreed that the official population estimate of 75 000 caribou in the WAH was grossly in error, and that there were 140 000 caribou within the boundaries of the vast NSB. The Borough's reckoning did not account for animals wintering south of the Brooks Range. There were, according to Mayor Hopson, two options: either the promised assistance to his constituents was to be provided in the near future, or the restrictions on hunting would be ignored.

My staff had assured me that although there were small numbers of caribou on the North Slope in early December 1976, some of which animals were near Barrow, they probably numbered less than 10 000 animals. Unfortunately, none of the caribou biologists were available during the holiday season. My superiors

instructed me to go to Barrow immediately for three purposes: to meet with Mayor Hopson, to determine the locations and abundance of caribou aggregations on the Slope, and to provide an updated status report on the situation.

The Commanding Officer at NARL was Richard Schaus. Richard Delefield was the chief pilot. Both of them rendered exceptional assistance. NARL was the only facility capable of providing the unique support necessary to conduct extensive aerial reconnaissance of the western North Slope during mid-winter. We flew in two NARL Cessna 180s on 3 January, one on skis and the other on wheels. Delefield and Patrick Walters were the pilots, and Hemmen, Valentine and I were the observers. We covered a large part of the western North Slope but found few caribou. That evening we met with Mayor Hopson and discussed the situation. The meeting was cordial but "stiff." I confirmed to Mayor Hopson that there were few caribou on the North Slope at that time, that it was in the best long-term interests of villagers to leave them alone, and that we would do what we could to speed up the delivery of assistance. We requested that Mayor Hopson send his own observers to help plan and participate in future surveys, which he did. Other biologists, summoned from their holidays, had begun arriving in Barrow that same day. It stormed on the 4th and 5th. I departed on the evening of 5 January, and the surveys continued as weather permitted, for another week.

This episode eventually concluded without additional caribou hunting and with the more expeditious delivery of food and other assistance. I believe that Mr. Dale Stotts, then a young advisor to the Mayor and a participant in later surveys, played a pivotal role in averting what would have been an unfortunate confrontation. Between 1976 and 1978 the WAH increased at a rate in excess of 15 percent annually.

LATTER-DAY PROJECTS

During various projects in the early 1980s after the Navy's departure, we used UIC-NARL mainly as a place to stay. The North Slope Borough's Department of Wildlife Management had moved its operations into the reorganized facility and was involved in research projects with bowhead whales. It appeared that under the new regime administering affairs of the Lab, considerable effort was being made to reestablish UIC-NARL as a center for arctic research that could be used by scientists from all parts of the country.

After retiring from the Alaska Department of Fish and Game in 1986, I became involved in a pair of



Fig. 5a. Soviet Icebreaker Moscow, racing to rendezvous with other Soviet vessels.



Fig. 5b. Unidentified Soviet submarine tender headed to rendezvous point.



Fig. 5c. Soviet tugboat awaiting arrivals of other Soviet vessels.



Fig. 5d. Our walrus survey aircraft during a low fly-by of the tugboat in Fig. 5c.



Fig. 5e. Closeup of helicopter flight deck and aft deck on Soviet Icebreaker, Moscow. One crewman on the aft deck in this view was the only person seen above decks on any of four vessels, during repeated encounters and passes on this day.



Fig. 5f. The target: a disabled Soviet submarine awaiting assistance.



Fig. 5g. Red and white symbol astern of the sail identifies the disabled Soviet submarine as a "nuke."

projects that utilized the UIC-NARL facilities to excellent advantage. One was a marine mammal monitoring program in the northern Chukchi Sea. Several oil companies, notably Shell Western Exploration and Production, Inc. (SWEPI) had progressed to the stage of drilling exploration wells in the offshore areas they had leased and explored using seismic profiling techniques. Test wells were required to determine if commercial deposits of oil and gas actually existed in the most promising offshore areas, which were near the migration routes of several marine mammals, particularly walrus. The drilling required a small fleet of specialized ships (Fig. 6), and was carried out during the open water seasons of 1989-1991. Continuous and intensive marine mammal monitoring was carried out while the fleet was in or near the pack ice (Fig. 7), both from shipboard and with aircraft based at Barrow and at UIC-NARL. The “scientific headquarters” for our project was the Lab.



Fig. 6. Breaking through heavy ice behind an icebreaker, Shell Western Exploration and Production, Inc. (SWEPI) drill ship Explorer III, and supply vessel proceeding in the Chukchi Sea, July 1991.

The other project dealt with non-marine subsistence resources of the central and western North Slope, sponsored by the NSB in 1988-1991. Dr. Thomas Albert, Senior Scientist with the NSB Department of Wildlife Management, foresaw the need for the Borough to compile as much information as was known about resources of importance to residents within the huge area known as the National Petroleum Reserve-Alaska (NPR-A). He correctly anticipated that at some point in the near future, the NPR-A would again be explored for commercial deposits of gas and oil, which in turn might lead to leasing, development and production. Residents of the region, particularly those dependent on fish and wildlife resources for subsistence purposes, would be directly and significantly affected. His goal was to insure that the NSB had access to all



Fig. 7. Pacific walrus on floes at the deteriorating southern margin of pack ice during the SWEPI project in the Chukchi Sea, 26 July 1990. Note that this scene approximates what observers had expected to find by checking out the radar target south of the pack ice 10 years earlier, when the target turned out to be Soviet vessels (see Figure 5). Photo taken from CANMAR icebreaker, Robert Lemeur.

of the available relevant scientific information to allow the Borough to protect critical fish and wildlife habitat as well as the animals themselves. I was asked to undertake that task, with help as required, from people in his department and elsewhere. The interesting departure from usual efforts to compile, synthesize and integrate this information was that the traditional knowledge of local subsistence harvesters, acquired over many generations, was also to be included in the data base. Three strategies were employed: 1) preparation of annotated bibliographies of all published reports about fishes, caribou and muskoxen, 2) a series of traditional knowledge workshops in each of the communities in or near the NPR-A (Pt. Lay, Wainwright, Barrow, Atkasuk and Nuiqsut), and 3) a series of scientific workshops, all held at the Lab, and involving local experts and other experts from Canada and the USA. The scientific workshops were designed as a means to capture information additional to that in the published literature, and to integrate that which was known to local residents and to biologists. Specific workshops dealt with anadromous and freshwater fishes, with fisheries enhancement, and with caribou and muskoxen.

I found the NPR-A project to be particularly rewarding on several different levels. High value was placed on local knowledge and understanding about the important subsistence resources. The local folks participated in and contributed to a broader understanding of the resources in question, visiting experts were extremely generous in educating us about methods and results of their respective ongoing studies, and both groups achieved mutual respect for the contributions

that each could make. The UIC-NARL setting for these meetings and for informal evening gatherings was ideal.

GRAY WHALE RESCUE

The most interesting challenge during the NPR-A project arose during the synthesis workshop on arctic anadromous fish, 25-29 October 1988. Just then, Barrow and UIC-NARL were coping with a worldwide media frenzy and the chaos swirling around three gray whales entrapped in sea ice near Point Barrow. This was indeed a poignant backdrop for those of us intently reviewing the biological significance of data on fishes and fish habitats vital to residents of Alaska's North Slope. Participants in the synthesis shared a belief in the long-term importance of the health of those fish resources; hence could be forgiven for thinking of our synthesis exercise as the most important scientific event taking place in Barrow in October 1988. Yet on the sea ice near UIC-NARL, and in dispatches beamed to television screens and newspapers around the world, Barrow's claim to fame was being forged differently: as a stage for dramatic gray whale rescue attempts. Encouraged by the glare of media attention, agencies, industry, and even Soviet icebreakers lavished efforts on clearing a path through the ice so that the two surviving gray whales could escape to open water and turn southward to the Pacific Ocean. The two dissimilar 'events' concluded on the same day. A decade later, at least a million times as many people remember the dramatic gray whale rescue as remember our scientific synthesis meeting. This contrast between two simultaneous events invites us to be thoughtful about the long-term role played by science in the Arctic, and about its public perception.

CONCLUSIONS

My most recent direct involvement with the Lab was in January 1993, when an important meeting of the NSB's Scientific Advisory Committee was held there. Again, village representatives and specialist experts from elsewhere participated. The issues involved the nearshore effects of industrial development in and near Prudhoe Bay.

Shortly after that meeting I recall thinking about the ever-changing dynamics involved with resource harvesting, conservation, animal rights, industrial development, and politics. Local communities are rightfully demanding more of a participatory role in the planning and execution of science projects and the interpretation and application of the results. On the North Slope, the UIC-NARL is still an important facility from which arctic science, primarily important to the interests of

Alaskans, is being planned and carried out. It remains to be seen whether the Lab can regain its prominence as a center for arctic science of broader national and international interest. Whether or not it does, the role it has played to date has been a great one. Its importance to me, personally and professionally, has been significant for reasons both tangible and intangible.

In retrospect, I am struck by how much my career exposed me to the Arctic. This exposure is striking for one who is basically not an arctic type of person. Except for its summer months the Arctic is too cold, too dark and too windy on average. My preference for the less predictable but kinder, gentler, more diverse and more productive subarctic regions is based on the relative frequency with which one arrives at a threshold for self-inflicted misery and discomfort. We can learn a lot from the animals we study. Mine primarily visit the Arctic in the summer, when briefly, it is a tolerably nice environment. Admitting that I am a subarctic type increases my respect for the hardy, truly arctic, personalities who enrich this account.

Many people, too numerous to mention, have been generous in offering their friendship, advice and assistance during my erratic forays north of Bering Strait. A few deserve special mention. This paper is dedicated to the memory of Raymond Aguvaluk and Waldo Bodfish of Wainwright, Harry Brower, Sr. of Barrow, and Drs. Otto Geist and Laurence Irving. Grateful thanks are extended to Lizzie Aguvaluk, Dr. Thomas Albert, Charles D.N. Brower, William and Mary Jane Kaleak, Dr. John Kelley and John Schindler. A special thanks is extended to Dr. Max Brewer, ruler of the empire at its zenith. Benjamin Nageak was always cheerful and helpful, as well as quick to remind me that when I first went to Barrow he was a laborer at the ARL. In more recent years he was my boss; first as Director of the NSB Department of Wildlife Management and later as Mayor of the North Slope Borough.

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The Barrow Cold Pipe Test Facility

Edwin S. Clarke¹

ABSTRACT: By hosting and assisting in the construction of an experimental facility in 1969, Barrow and NARL played a little-known role in exploring engineers' options for design and operation of the pipeline that eventually transported Alaska crude oil from Prudhoe Bay to Valdez.

Key Words: Trans-Alaska Pipeline System (TAPS), permafrost terrain, arctic soil dynamics, polygonal cracking, ice-rich silts, tensile failure, soils engineering

INTRODUCTION

The discovery of crude oil in 1967-68 at Prudhoe Bay prompted engineers to consider a number of options for transporting the oil to markets of the world. These options included tankers and railroads. People today tend to take for granted the design of the Trans-Alaska Pipeline System (TAPS), which had to be designed foot-by-foot for the localized soil conditions encountered along its route.

A number of concepts relating to crude oil transportation in the Arctic grew out of experience gained at the Naval Arctic Research Laboratory (NARL). Faced with the task of designing a pipeline to transport the North Slope crude oil, pipeline engineers from the owner companies approached Engineering faculty at the University of Alaska in 1969. Led by George Knight, P.E., Ph. D., the research team was tasked with determining how to build a pipeline across several hundred kilometres of thaw-unstable Alaska permafrost terrain. Two fundamentally different options were discussed, distinguished by whether the oil in the line would be hot or cold as it made its journey to the ice-free port of Valdez. This paper discusses work at NARL to evaluate the cold oil pipeline option.

COLD PIPE TRANSPORT AND GROUND FORCES IN PERMAFROST

Concerns about heat transfer from a hot-oil pipeline to the permafrost terrain forced design engineers to focus on the concept of a cold oil transport system. This concept involved cooling the oil from its reservoir temperatures to below freezing (0°C) and transporting it in a buried pipe. Preliminary consideration of this idea by engineers familiar with arctic soil dynamics indicated that the ground forces could cause the pipe to fail.

The potential fatal flaw in the cold pipe option was the fact that the pipe was to be frozen rigidly in the permafrost soils. The steel pipe would be subject to the tensile forces generated by polygonal cracking characteristic in ice rich permafrost soils. As the ground cools and contracts, tensile failure occurs at the weak planes in the soil wherever clear ice is encountered.

Polygonal cracking occurs annually. At the onset of winter, air temperatures at the surface fall far below freezing. Ice rich permafrost beneath the tundra cools, contracts, and fractures. The resulting vertical crack is wide at the ground surface and gradually narrows with depth as it propagates away from the cold surface, as subsurface soil temperatures increase (Fig. 1). These cracks remain open until the spring thaw when snow-melt water flows into them from the surface and re-freezes. The following winter when the ground contracts again, tensile failure occurs at the same vertical crack.

Cycles of repeated cracking and addition of water during spring runoff result in the growth of an ice wedge. As many ice-wedges intersect one another, they form polygons which are on the order of 10 to 100 m in diameter. The polygonal pattern is readily visible from the air. The top of the wedge can range in width from 0.5 to 2 m (2 - 6 ft.). The wedge may extend vertically from 3 to 5 m (9 - 15 ft.).

TEST SITE SELECTION, ACCESS, AND CONSTRUCTION

Alyeska Pipeline Service Company commissioned University of Alaska researchers to evaluate the magnitude of the wedge-generated tensile forces and to determine their effects on a buried pipe. A section of prototype pipeline was constructed south of NARL

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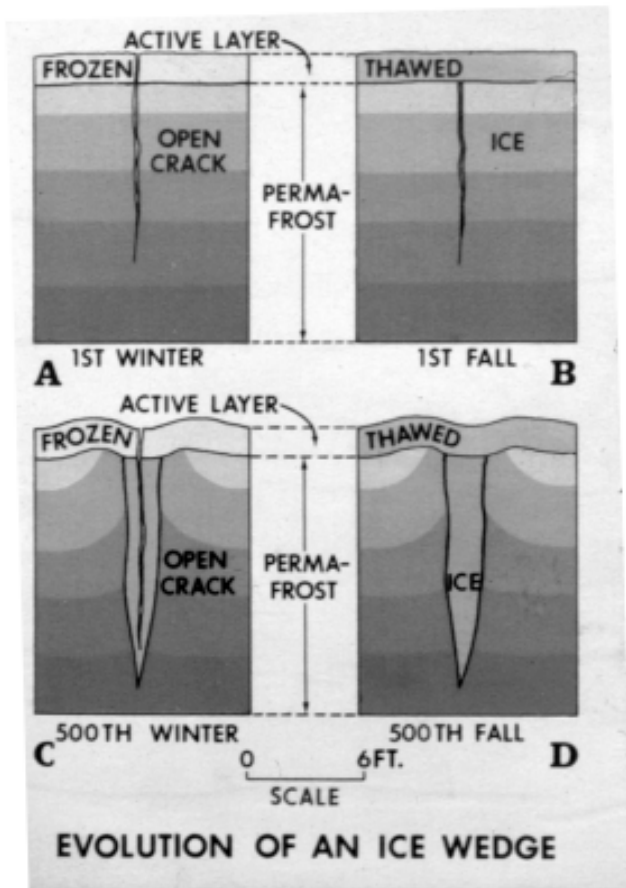


Fig. 1. Diagram of the evolution of an ice wedge by winter crack-widening, top-down, and summer filling of the crack with melt water, also top-down, over a 500-year interval. Diagram, Louisiana State University, courtesy of H. J. Walker.

and several programs were conducted to evaluate these forces on a cold pipe.

Prior to snowfall in 1969 Ralph Migliaccio, then a geologist with the University's Institute of Arctic Environmental Engineering (IAEE), made an aerial reconnaissance of the area. The final site selection was based on the presence of polygonal ice lenses and the proximity of logistical support (Fig.2).

A snow road was used to provide access to the site during the winter months. This snow road was maintained by periodically grading the snow covered terrain with an open lattice of steel beams towed behind a D7 or D8 Caterpillar tractor. All the materials and equipment used for site construction were moved over the snow road with virtually no impact on the tundra.

The road was marked with stakes placed at intervals of approximately 100 feet (30 m). If any of these stakes were missing or buried during a blizzard it was necessary to sight back on the existing stakes. During the summer months tracked vehicles including weasels were used to travel across the tundra.



Fig. 2. Surface view of the location of the Barrow Cold Pipe Test Facility, running between two instrumented buildings, 1969.

Burgess Construction Company out of Fairbanks, which had recently paved the runway in Barrow, was selected to build the pipeline test section. Construction was started in September of 1969 and was mostly complete by December of that year. The main test section consisted of a 305-m (1000 ft.) length of 102-cm (40 in.) diameter pipe, 244 m (800 ft.) of which was placed in a ditch excavated in the ice-rich silts.

The ditch was excavated with ripper tractor with the lower portion of the ditch in frozen gravel. The remaining 60 m (200 ft.) of pipe was placed in a gravel berm. The two segments were connected by an overbend and a sagbend. An access point was placed at the midpoint of the pipe. This consisted of a 4 square-foot (0.375 m²) opening in the pipe with a 2-m (6 ft.) diameter asphalt tank placed vertically over the opening.

Pre-constructed NARL wooden buildings were placed at each end of the pipe (Fig. 3). The NARL power grid was extended from a gas well to the site. This provided all the site power including electric heat. Construction continued through several storms at the site. Significant snow accumulation in the open trench required re-excavation of the trench. The trench was backfilled with the excavated soil and was saturated with several loads of hauled water to ensure that the pipe was rigidly locked in the ground.

TEMPERATURE MEASUREMENTS, TRANSDUCERS AND DYE STUDIES

The thermal regime around the pipe was monitored by several thermocouple arrays, placed in PVC tubes inserted in previously drilled holes. Each array consisted of several sets of vertical probes installed to a



Fig. 3. George Hochshield and Staples Brown, outside one of the instrumented pre-fabricated wooden instrument huts provided by NARL.

depth below that of the pipe. These were located on each side of the pipe.

The forces in the pipe were measured with triaxial strain gauges epoxied to the inside of the pipe (Fig. 4). These were connected to cables which were, in turn, connected to readout devices in the instrument buildings. Both the thermocouples and strain gauges were read with a null-center Wheatstone bridge (Fig. 5).



Fig. 4. Strain gauge, welded inside test pipe.

A first-order survey was made both inside and outside the pipe to monitor any movement. The survey inside the pipe was made using mining equipment to illuminate the theodolites. The rodman had to use a flashlight to illuminate the sighting point. Personnel working in the pipe used mechanic's creepers to traverse the pipe (Fig. 6).

The transducer study was an attempt to quantify the forces generated by the polygonal cracking. A 3-m (10-ft.) section of 0.3-m (12-inch) pipe was instrumented with strain gages in Fairbanks and was flown to Barrow. Additional lengths of 0.3-m pipe



Fig. 5. Bill Powell, electronics technician, zeroing strain gauges.

were welded to extend the instrumented section. At the end of these extensions additional pipe was welded perpendicular to the extension to form a T on each end. These transducers were buried in trenches dug across previously mapped ice wedges.



Fig. 6. Dr. John Morack observing strain gauge inside the test pipe.

The strain gauges were attached to a recording paper strip chart in attempt to determine the rate at which the ice wedges cracked apart (Fig. 7). The test procedure required removal of the snow during a cold-weather period and replacing the paper at 12 hour intervals. Two research personnel spent New Year's Eve this way.

One of the techniques used to determine the presence of cracking in the vicinity about the pipe was to fill surficial cracks with red food coloring and ethanol alcohol. Subsequently a 90-cm (36-inch) hole was drilled near the pipe and the investigator excavated to the pipe-ice interface in an attempt to determine whether soil was in direct contact with the pipe. This provided a subjective indication of the strength of the adfreeze bond between the pipe and the soil.



Fig. 7. Bill Powell, electronics technician, operating strip recorder used for transducer study.

TEST RESULTS

None of the strain gauge readings indicated the sudden strain commonly associated with steel pipe failure. There appeared to be a mechanism which reduced the adfreeze bond between the pipe and the soil. It was hypothesized the sudden temperature change caused the pipe to contract faster than the soil. Thus, we discovered no evidence for the “fatal flaw” concept associated with polygonal cracking. In other words, the project left open the possibility that fluids chilled to the freezing point of water could be transported safely through steel pipelines in ice-rich permafrost soils.

While these tests were progressing, engineers elsewhere concluded that other problems associated with cooling crude oil below freezing might not be solved. They determined that it was not feasible to extract the enormous quantity of reservoir heat from the oil before pumping it. A second problem was that chilling the oil could have resulted in an increase in pumping costs. The use of an elevated pipeline was gaining greater acceptance in the pipeline design community. As a result of these developments, the Barrow Cold Pipe Test Facility was placed in a maintenance mode.

DECOMMISSIONING

By 1974, plans were well underway to build the partially elevated hot oil pipeline in use today. The sponsors of the project elected to decommission the cold pipe test facility. The test pipe was filled with water and allowed to freeze. All the surface accessory features were removed and the site was leveled and re-vegetated.

NARL provided much of the logistical support for the project. During its winter construction, experienced NARL personnel provided practical guidance that prevented numerous blunders. The creature comforts and the good food provided by NARL improved the morale of all the workers. Kenneth Toovak, Sr. allowed research personnel to use weasels and trucks with the attitude of a concerned parent allowing a sixteen-year-old to drive a classic antique car. A number of Barrow residents participated in the construction of this project. Most notable is William Leavitt who worked on both the construction and in the data acquisition phase as the resident site manager.

NARL's Scientific Legacies Through Outer Continental Shelf Environmental Studies

David W. Norton¹ and Gunter Weller²

ABSTRACT: Methodology, developed at NARL for encouraging interdisciplinary teamwork among researchers, was adopted in marine bioenvironmental studies beginning in the mid-1970s. The authors trace investigative teamwork to the present, and suggest that its roots reach back to NARL's formative years.

Key Words: OCSEAP, process studies, Endicott Field, Arctic cisco, *Coregonus*, Simpson Lagoon, environmental assessment, British Petroleum, North Slope Borough, Science Advisory Committee

In 1975, NOAA-OCSEAP (National Oceanic and Atmospheric Administration-Outer Continental Shelf Environmental Assessment Program) was two years into organizing and conducting environmental studies of Alaska's continental shelf regions. These studies were mandated by the accelerated federal initiative to lease submerged lands for oil and gas exploration. Project [energy] Independence had been proclaimed by the Nixon administration as its means to decrease U.S. dependence on imported petroleum resources after the 1973 oil crisis. Alaska's most promising offshore region was the Arctic, specifically the Beaufort Sea. Logically enough, industry was most interested in leasing tracts of submerged lands adjoining the Prudhoe Bay field. By contrast with the Gulf of Alaska and the southern Bering Sea regions, ice-dominated shallow waters of the narrow Beaufort shelf were essentially out of reach by conventional logistics. Great distances from homeports, short ice-free operating seasons, and shallow water defied the sorts of pre-leasing environmental studies that elsewhere relied on classic shipboard techniques and deep-draught oceanographic vessels.

The Beaufort Sea, at least temporarily, had thus baffled conventional physical, chemical, and biological oceanographers. Instead of oceanographic vessels, Beaufort Sea environmental investigators would work from smaller platforms, down through the NARL-based *Alumiak* and *Natchik* (Dronenburg, this volume), to the size and minimum draughts of skiffs and waders. As managers of OCSEAP's Arctic Project Office, we rallied proven arctic experience from disciplines beyond oceanography. We turned to the human

resource capital represented by investigators experienced during NARL's support for team research during the 1960s and 70s. The Tundra Biome of the International Biological Programme (IBP—Brown, this volume) and AIDJEX (Arctic Ice Dynamics Joint Experiment—Weeks, this volume) served us as models for encouraging integrated investigations. We advocated integrated studies of ecological processes for key subsystems of the nearshore Beaufort Sea shelf in the path of oil and gas leasing: in effect, a sea-going adaptation of IBP's Tundra Biome.

Our prime example of turning to integrated studies was an OCSEAP Request for Proposals that resulted in the four-year Simpson Lagoon ecological process studies, led by LGL Ecological Research Associates in the years 1976-79. That firm brought extensive arctic experience in Canada and Alaska to the studies in Simpson Lagoon (Fig. 1). Its ecologists blended well with what grew into a close-knit community of arctic OCSEAP investigators. Many were NARL veterans, and all were intrigued by the scientific challenge of figuring out how the Beaufort Sea shelf should be perceived, either as one system, or as a series of semi-distinct ecological subsystems.

Several forces kept these studies from becoming "blue sky ecology" in their formative years. First, we never lost sight of the industry's rational agenda for exploring and producing oil and gas by stepping cautiously outward from the arctic mainland to islands and submerged lands. Second, LGL scientists exercised self-restraint in investigations they undertook, by using C. S. Hollings' (1978) iterative pattern for Adaptive Environmental Assessment (AEA). That is, they first evaluated the vertebrate consumers directly interesting to humans—fishes, waterfowl, and mammals—that used Simpson Lagoon and the Jones Islands. Only

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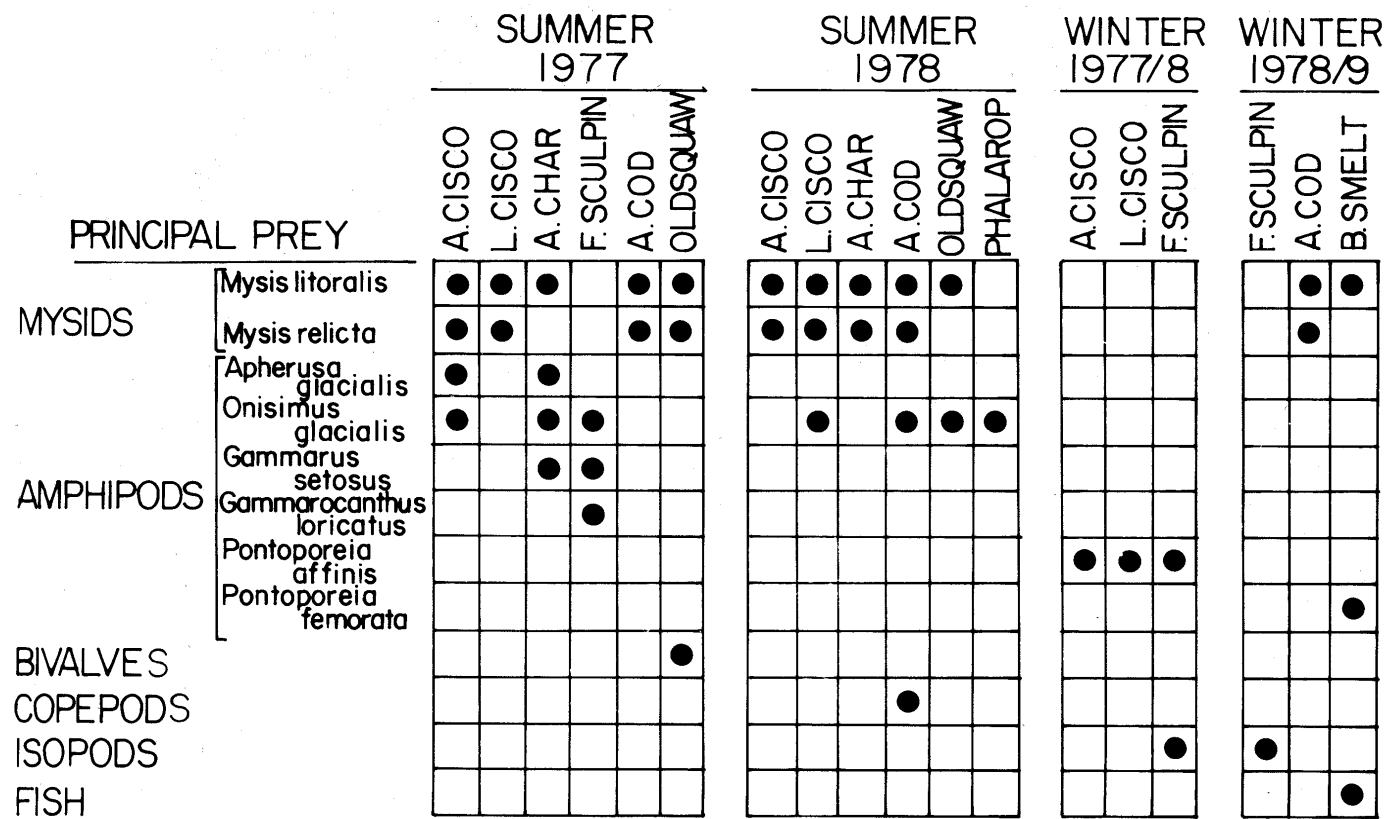


Fig. 1. One of many products of Simpson Lagoon process studies: synthesis and summary of seasonality among lagoon-using biota. Source: Arctic Project Office, NOAA-OCSEAP.

when those consumers were shown to be dependent upon particular food resources, did investigations address levels lower in the ecological pyramid, to examine natural history, ecological, chemical, and physical processes that supported the food species (Fig. 2).

LGL’s approach began and remained open-minded, if not open-ended. During the OCSEAP phase of investigations, that approach assumed a degree of intellectual adventure. Don Schell of the University of Alaska’s Institute of Marine Science was adopted into the comity of investigators to apply radioisotope techniques to documenting food web relationships—a then-pioneering form of ecological chemistry. Years after OCSEAP’s role in research design and management was over, LGL invited geneticists from Texas A & M University to apply protein serological and mitochondrial DNA analyses to the question of stock identities among anadromous fishes using the nearshore zone. Simpson Lagoon studies attracted participation from all institutional sources: a blend of government agencies, universities, and private firms contributed. Collaborative research included a series of Beaufort Sea Synthesis meetings, the first of which took place here at NARL (Weller et al. 1977); these meetings also included scientists from the petroleum industry.

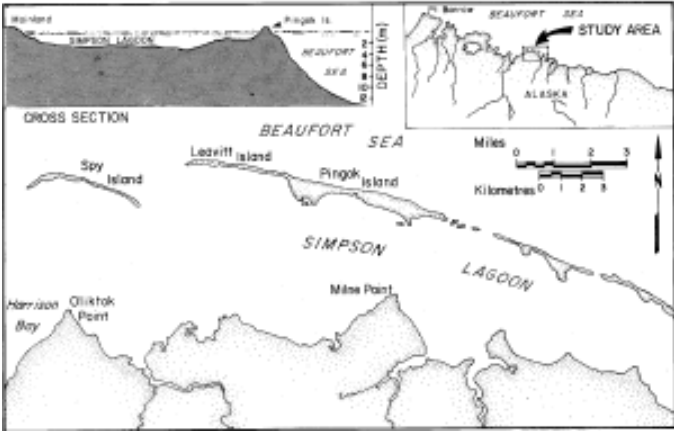


Fig. 2. General location for NOAA-OCSEAP intensive sites, 1976-79, in barrier island-lagoon process studies, similar to earlier biome studies supported by NARL.

Several conclusions were drawn from these Simpson Lagoon process studies:

- a) Lagoon-barrier island systems in the Beaufort Sea are biologically productive compared to the open ocean seaward of the islands, especially for feeding and growth processes among anadromous fishes;
- b) productivity of lagoons is sustained by the long-term exchange of nutrients through

gaps and passes between islands, in an episodically wind-driven system, as well as by seasonal inputs from terrestrial sources;

- c) seasonal or short-term lagoonal biological productivity depends not on conventional in situ primary productivity (phytoplankton), but on maintenance of an alongshore plume of warmer, less saline water, combined with the mixing of marine and aquatic invertebrates and other resources;
- d) although productive, lagoonal systems were shown to be relatively insensitive to coastal modifications that industry wished to make—gravel manipulations, island-joinings, and causeway and island construction. Chemical pollution, by contrast, was considered as disruptive to arctic lagoons as it could be anywhere. (LGL, 1980).

As these Simpson Lagoon process studies for OCSEAP were concluding, the so-called West Dock in Prudhoe Bay became an irresistible target-of-convenience for seaward extension. Secondary oil recovery with saltwater injection, called the Waterflood Project, required intakes to be placed far enough offshore to reach liquid water under maximum winter thickness of sea ice. The third seaward extension of West Dock in 1981 raised agencies' concerns for some of the key vertebrate resources that use nearby Simpson Lagoon, as documented by LGL's initial studies. Anadromous fish populations, notably the Arctic cisco (*Coregonus autumnalis*) depend on lagoon systems for feeding (Fig. 3). Over five to seven summers, fish grow to sizes catchable in the subsistence fishery by the community of Nuiqsut on the Colville River to the west of Simpson Lagoon. By the early 1980s, Arctic cisco were known to overwinter in the Colville River, and each spring to disperse east- and westward through the Beaufort barrier island-lagoon systems. Each autumn, they return from summer estuarine habitats to migrate back upstream in the Colville River, there to remain inactive for months beneath river ice in limited overwintering habitats.

Resource agencies grappled with permitting the West Dock (causeway) extension for Waterflood: what if a solid-fill causeway impedes Arctic cisco movements alongshore to and from lagoon systems, and reduce the recruitment of catchable-size fish into the Colville fall fishery? Meanwhile, LGL's fishery biologists were absorbed by a scientific puzzle. Where do Alaska's

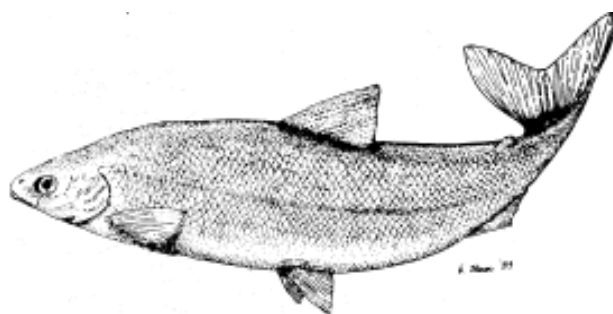


Fig. 3. Follow-on to NOAA-OCSEAP studies: anadromous fish use of nearshore lagoon, and riverine systems of the Western Beaufort Sea. Cover drawing by Betsy Sturm, for Biological Papers of the University of Alaska 21, 1983.

Arctic cisco populations spawn? After fruitless searches for spawning by this species in Alaska, LGL (Gallaway et al., 1983) proposed the now accepted hypothesis that Arctic cisco in the western Arctic all originate from eggs spawned in Canada's Mackenzie River system.

In 1984-85 British Petroleum designed and constructed a new 8-km causeway, with breaches, from the delta of the Sagavanirktok River out to the Endicott Field. Long-term monitoring studies of the effects of Endicott and West Dock Waterflood causeways and their mitigative breaches have continued to increase the understanding of nearshore fish ecology through 1997 field season. LGL has continued its leadership of investigations with this new focus.

With varying persistence, other organizations and agencies have carried forth the process studies begun in 1976-79 under OCSEAP. The North Slope Borough's long-term commitment has been unique among agencies. Its Department of Wildlife Management and its Science Advisory Committee continue to work with the scientific team and with their current funding source, BP Exploration (Alaska) Inc. Throughout the several phases of this work, from the kernel of an idea originating at NARL during OCSEAP days, through the Waterflood causeway extension, and most recently the Endicott phase, researchers have explored many facets, both practical and basic, of arctic nearshore marine systems.

Wilson and Gallaway (1997) review the history and evolution of these areas of understanding. Achievements growing out of this scientific team's perseverance include dozens of peer-reviewed scientific papers. The review itself is an account of research continuity. The part of the story untold by Wilson and Gallaway's review is how OCSEAP's arctic ecological process

studies began in the first place. We have shown here that they were an outgrowth of the NARL-based experience of nurturing cooperative investigations.

From contributions to this volume, and from conferring during the 50th Anniversary events with people who shaped NARL's institutional attitudes toward science, it becomes evident that we should acknowledge continuity further back in time. We were reminded in 1997 that current arctic investigators owe much to the style of Dr. Max Britton's leadership from the Office of Naval Research (ONR). Even now, a number of years and steps removed from his direct personal contact, science bearing the Britton style and philosophy is manifest in the Arctic. His style of guiding research (more than managing it) persists wherever investigators are trusted to plan and execute work in the best interests of the arctic community as a whole.

Preceding Max Britton's tenure at ONR, Dr. Laurence Irving himself imparted a special brand of NARL momentum to decades of future research. Elsner (this volume) portrays Larry Irving and Pete Scholander as "giants of 20th century science." Neither of these giants was a lone operator: indicative of NARL style, Elsner's lists of their early papers on cold adaptations and fossil atmospheres show that Irving and Scholander each acted as members of collaborative teams of investigators. We suggest that investigative teamwork, in the Irving-Scholander mold, was a NARL hallmark that dated from the laboratory's founding in 1947. Max Britton refined the style at a management level; others carried it on through the Tundra Biome (Brown, this

volume) to OCSEAP, and we have shown that the lineage survives to the present. NARL's first half-century of contributions thus unfolds as a richly illustrated endorsement for George Newton's (this volume) recommendation that collaboration be a distinguishing strength of future scientific undertakings in the Arctic. In summary, we trace one theme of arctic scientific achievement now spanning three decades since OCSEAP. We submit that its foundation could not have been laid without the *camaraderie* that NARL cultivated among scientists who associated here.

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Alumiak and Natchik: An Account of Shipwrights and Seafaring at NARL

Ray Dronenburg¹

ABSTRACT: In the late 1970s, NARL took on the challenge of enabling other agencies to conduct vessel-based research in shallow nearshore marine environments. This account traces the ordeals of refitting two older vessels, then operating them effectively and safely along Chukchi and Beaufort seacoasts to support bioenvironmental research.

Key Words: Alumiak, Natchik, boat operations, bottom-sampling, sonabuouys, bowhead vocalizations, BLM, IWC, AEWC, OCSEAP

I went to the Naval Arctic Research Laboratory late in 1976 to assume the duties of “boat operator.” The events surrounding my introduction to Barrow and NARL proved unforgettable. I can still recall my Mother sticking her head out the door of her home in Washington State to announce that there was an “Eskimo on the phone for you.” The ‘Eskimo’ turned out to be the very French lady, Nicole, secretary to Dr. John Kelley, the Director of the Lab who was offering me this dubious position of “boat operator.”

Arriving in Barrow in late fall is a culture shock, regardless of where you come from. For that matter, arriving in Anchorage on Seward’s Day was a shock. (“What is a Seward’s Day and why can’t I cash a check?”) Flying on to Barrow, the pilot began playing his harmonica, and “bumped” us at the Arctic Circle. Everyone on the airplane seemed to know one other. It was certainly like nothing I had ever experienced before.

I was met at the Wien Air Alaska terminal in Barrow by “Frenchy.” Frenchy was Nicole’s husband and he was every bit as French as she. In all my life, previous and subsequent to Barrow, I have never met anyone like Frenchy. He was the happiest, fastest, most aggressive, likeable man friend I have ever known. On this day, he carried with him a very large warm parka, just for me. Thank goodness, because the imitation leather coat I had worn from Washington State cracked as soon as I walked off the plane into arctic winter temperatures. For readers unfamiliar with the old Wien terminal in Barrow I shall describe it as a small 20-foot by 20-foot, single-storey building. Its main room had blankets hung in opposite corners to provide some degree of modesty for the person using the “honey buckets” concealed behind them. A honey

bucket was (and still is in many parts of Alaska) the toilet.

Frenchy took me from the Wien terminal in a truck marked with a sticker indicating ownership by the Atomic Energy Commission. We drove through the village of Barrow, out through Browerville and onto the beach road toward the Lab. It was cold, the wind was blowing, and there was snow. Entering the Naval Arctic Research Laboratory, the road crossed a bridge that was partially blown shut from drifting snow. You can imagine that the picture was a bleak expanse of white blowing, drifting snow. Frenchy knew of my assignment and took the trouble to drive over to my new command.

The *Alumiak* (of course, she wasn’t the *Alumiak* then – the name came later) was beached, with snowdrifts covering most of her starboard side. I had not been told that the main propulsion consisted of two large outdrive units (Fig. 1). They stuck out of the hull like twin turtle heads out of a shell. She did not appear to be a happy vessel. With a flat bottom, 85 feet in length, built of 3/8-inch Aluminum, covered with a flat deck that protruded over the bow, or “pointy end,” the *Alumiak* had been listed in “Janes’ Fighting Ships” as a light-weight warping tug. The U.S. Navy had built two of these ships for the purpose of lightering docking material into small bays for landings in enemy-controlled situations. Later I was to form my private opinions as to why the Navy had given the vessel to the Lab. At this first sight of the frozen hulk my already limited enthusiasm for the new command diminished even further.

Dr. John Kelley is an extremely dedicated scientist. He foresaw the need for a work platform (the *Alumiak*) as fulfilling the Lab’s essential role in Outer Continen-

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Fig. 1. The *Alumiak*, one of two aluminum-hulled light-warping tugs constructed by the U.S. Navy, as it appears in winter hauled up on the Chuckchi coast at NARL, with its outdrives perched in the up position. BASC Photo, by D. Ramey, January 2000. (See also, Laursen et al., this volume: Fig. 7.)

tal Shelf Environmental Assessment (OCSEAP, Norton and Weller, this volume) investigations of the Chuckchi and Beaufort Seas. Eager to accomplish this task, Dr. Kelley had accepted the light warping tug, and “assumed” that the vessel would be up to the tasks at hand. The tug’s design—flat-bottomed, with drive shafts that could be raised to navigate shallow water—was ideal for the tasks, at least in theory. The Beaufort Sea is quite shallow along the coastline, especially in and around the barrier islands. Also the shallow draft should allow the light-weight warping tug to run in close to shore, navigating early-season moats between grounded shorefast ice and the beach (again theoretically).

Meeting John in those days was a treat (our personal and professional friendship over the past twenty years allows me to call him John). John sat behind a large desk and smoked a pipe. It made his office very aromatic, although he always had trouble keeping the darn thing lit. Visitors on business tended to become so interested in his manipulations of the pipe—the tampering, the lighting and then the smell—that we sometimes forgot what the heck we were supposed to talk about. John filled me in on the background of the *Alumiak*. Joining us in the aromatic office was Ned Manning. Ned held the position of Marine Superintendent making him my immediate boss. More about Ned later. John told me that the previous year a man named “Shipwreck Kelly” had operated the *Alumiak*. From what John told me, Shipwreck had not had a good season, had driven the *Alumiak* home, run her up on the beach and fled (figuratively) screaming into the night. I don’t recall, from that conversation, any discussion of specific mission successes or failures from the first voyage, but I can now imagine that

failures prevailed. (Far be it from me to sound critical: I judge failure in the High Arctic as a sign of trying.)

The following day Ned Manning introduced me to Roy Nageak and Joe Ningeok who would be working with us. Roy and Joe were locals – young men later to become community leaders. Roy’s Brother Benny also worked with us occasionally. Benny would be elected North Slope Borough Mayor in 1996 and Roy would assume many directorships over various programs. Over the next thirteen years Roy, Benny and others would become my very good friends and help me learn an Iñupiat life style. Ned and I drove over to the *Alumiak* and struggled aboard. The engine room in the *Alumiak* sits aft. The vessel sat stern down. I was later to learn that the stern was only some ten feet (3 m) from the edge of the Chuckchi Sea which at my arrival had frozen over solidly, and was difficult to distinguish from the beach on which the *Alumiak* sat. The reason for mentioning this location is that after “Shipwreck” drove the *Alumiak* to the beach during the summer of 1976, D10 dozers had winched or dragged the *Alumiak* just a little farther out of the water. Her stern had been subjected to pounding surf and freezing spray during fall freezeup in 1976.

That first day, we examined the engine room, finding that the two V8 Detroit Diesel engines and hundreds of pumps, motors and electrical equipment, were thickly encased in frozen salt water. The ice level was about midway up the Detroit diesels. The sight did not give the new Captain a warm and fuzzy feeling for his vessel. Ned, on the other hand, suggested that because the engines were totally submerged and not subject to air and oxidation, probably—maybe—the engines could be salvaged. Here I should characterize Ned Manning as not only a mechanic, but in my humble opinion, a genius. I later learned that Ned was dyslexic. He struggled long and hard to read a book and had not done well in school. Nevertheless Ned could work magic on a hunk of metal – making intricate parts for machinery and applying his amazingly profound understanding of diesel engines. Ned and his knowledge formed the glue that kept us all persevering in the belief that we would eventually salvage this vessel. Our first undertaking was to use Herman Nelson heaters to thaw out the engine room. These heaters—common as household tools throughout rural Alaska—use kerosene as fuel to blow extremely hot air over cold-soaked machinery. (The joke prescription for disenchanted Alaskans seeking to escape frustrations of the North is to tow a Herman Nelson behind their car. Only when someone asks, “what’s that?” can they be sure of having escaped far enough south.)

Joe and Roy set about melting the ice encasing the machinery, and pumping out water liberated by the thawing process. Ned and I began trying to figure out how the boat worked (what made the outdrives go up and down, how the steering worked, etc). There were no plans or drawings. We simply had to crawl around on hands and knees following lines to see where they connected. Within a few days we had the boat pulled farther up the beach and were hooked up to a power drop for electricity. Eventually we could see all of the engine room and the bilge. Ned immediately began to concentrate on the engines. One day, several weeks later, they roared back to life, as if in tribute to Ned's patient genius.

With our ability to run the engines, our next challenge was to generate hydraulic power to lift and turn the outdrives. Now the fun began. For those persons who have never been victimized by a blown hydraulic line in a confined space, let me try to describe our predicament. The hydraulic system for the *Alumiak* was intricate, extensive, complicated and nearly impossible to work on, much less understand. To get to the hydraulic system, we crawled over the top of a Detroit diesel to the stern of the vessel. There, lying on one side with arms extended, we attempted to replace a hose or work with a valve, using short movements, grunting, and lots of four-letter words. Whenever a hose exploded, a pink cloud magically appeared. The smell was obnoxious (sweet and sticky) and the pink mist permeated our clothing and clung to our skin. An exploded line meant someone had to mop up the mess, replace the hose and start over. There were close to a hundred yards of hydraulic hose on the *Alumiak* – all in various sizes and lengths. We eventually had to buy hydraulic lines in bulk, along with fittings, so that we could make up our own hoses rather than attempt to order them long-distance and suffer the delays. Two more months resulted in total failure. We were baffled.

We kept telling ourselves that the Navy engineers who had developed the *Alumiak* must have been pretty good at their jobs, but each failure weakened our conviction. First, we had no schematics to tell us what moved what or basically how the system was designed to work. Second, each time we thought we had figured it out, each test blew another line. We must have gone through several hundred gallons of hydraulic fluid. One day we decided to look into the accumulator tank. The hatch cover was outside on the stern. After removing some thirty bolts we attempted to remove the cover only to find that the rubber gasket had turned into something like molasses; nothing but long strings of melted rubber remained. What in the world was

causing this? Looking through the ship's log we discovered that during the summer of 1976, "Shipwreck's" crew had taken aboard two drums of JP-5 turbine oil. Turbine oil is used as helicopter fuel. It's sort of slick and has the consistency of syrup. The stuff in the hydraulic tank tested out as turbine oil, so we guessed that the ship's crew had, for some reason, used turbine oil in the hydraulic system, instead of hydraulic oil. The results were that anywhere the turbine oil touched rubber, the rubber melted. Thereafter, the melted rubber flowed until it found a home in one or another hydraulic valve. Clogged valves created a backpressure, which pressure, in turn, ruptured the lines. We thereupon replaced the fluid in the main tank, replaced every hydraulic hose in the system (many for the third and fourth time) and cleaned and reinstalled every valve. Upon activating the system for testing we found that we could now turn, raise and lower the outdrives: after months of frustration with propulsion and steering, we were in business.

Sometime during the weeks of frustration, we had chosen to hire a wonderful gal by the name of Selena Brotherton and a guy named John Cronin. John is now a prominent practicing engineer in Fairbanks, but unfortunately I have lost track of Selena over the years. Their jobs were to redesign the living quarters on the *Alumiak*. I wanted individual bunks for fifteen people with the capabilities for cooking and toiletries. I wanted the cabin to have workspace for scientific efforts provided with power for computers and other specialized equipment. On deck, John Kelley wanted space for a "helo" hut – a blue lab-hut capable of supporting research tasks in comfort on deck. We knew the *Alumiak* had operated during the summer of 1976 long enough to raise concerns for her short operating range, hence high frequency of re-supply needs. Drinking water and fuel oil were the prime concerns. We purchased a large rubber bladder and installed it in a frame forward of the living quarters to provide plenty of water. For fuel, Ned came up with the idea that we should cut a hole in the foredeck and, by using two frames forward of the fresh water hold, install baffles and fill those holds with fuel. His genius with a cutting torch, and precision in drilling holes and matching those holes to his new hatch cover, gave us our long-range fuel storage. For baffling we used 55-gallon drums with lots of pickaxe holes in them. Baffling was to keep the fuel from sloshing back and forth. The compartments were already fitted with piping to draw the fuel for use in day tanks.

It was now spring 1977, and our efforts were showing that the *Alumiak* potentially should work. There

was a slight concern on the part of the Captain that we had miscalculated the weight and balance for the fuel and water, and might float with a 30-degree down angle forward, but why spoil everyone's new optimism with my doubts? I should mention that by now Ned had convinced me to take on the position of Marine Superintendent along with that of skipper so that he could go back to being just a mechanic. (Ned could never be 'just a mechanic.') Upon getting everything working, we decided that a celebration was in order. NARL folks never needed much of an excuse to have a party. This party's theme was naming (remember, the *Alumiak* was not the *Alumiak* yet) and launching the vessel. We planned a contest to name the vessel—and why not also stage a “Ms. Vessel” contest? (No bathing suit parade – simply a vote by the NARL family).

I haven't mentioned her yet but there was a Mrs. Ned by the name of Sally. Sally, like so many ladies at NARL, was a wonderful lady who loved to cook and sew but also loved her wolf. She and Ned had taken on the responsibility of raising a wolf pup, which they kept in a pen in the front of their Quonset hut. This young wolf was a huge male who got fed by each passing NARL employee. On regular occasions he took Ned and Sally for walks. (Any witness to one of their outings would know how absurd it would be to assume that I meant to say that Ned and Sally took the wolf for walks.) I do not recall the wolf's name, but to see him run freely was a most magnificent sight. Sally won the contest and was chosen as Ms. *Alumiak* after the vessel was officially christened *Alumiak*. This name is a contraction of the words 'aluminum' out of which the hull was constructed, and '*Umiak*' (Inupiaq for canoe or skin boat).

Equipped with a vessel apparently ready for action, and bearing an official name, we now had only to wait for breakup. For a seafarer to see the ocean for the first time, after it has been ice-covered for months, is truly a wondrous experience. One day it simply is out there, blue, moving, and dark, while white and glaring ice drifts away over the horizon. We hooked up six D9 'dozers (three to a side) and using their winches, began sliding the *Alumiak* back toward the Chuckchi Sea. The occasion brought out the entire NARL family. With one-inch cables snapping, engines roaring and crowd cheering loudly, I stood on the bridge and orchestrated the movement like a conductor before a large symphony orchestra. (At this point I should give credit to a very good friend who was truly the symphony conductor, Frankie Akpik. Frankie is a local who has been around the NARL for what seems

centuries. Everyone knows him, respects him and listens intently when he speaks on any subject. He is a noted Boat Captain, Cat Skinner, Cold Weather Expert and Jack of All Trades. To say he is a character is putting it mildly. Later in the summer it was Frankie who took my Diana Hunter (a lady whom I would later marry) water skiing from NARL to Point Barrow – a feat that probably belongs in the Guinness Book of Records.) With the 'dozers now knee-deep in the Chuckchi Sea they finally had the *Alumiak* launched to the point that only the bow perched on the shoreline (see Laursen et al., this volume: Fig. 7).

I noticed that the bow seemed to be riding very low and was concerned that when backing the vessel from the beach the bow would continue downward until it was awash or under water. Nobody else learned of my anxiety. Frankie parked the dozers to give me ballads to tie to. We lowered the outdrives and started engines. The *Alumiak* was alive and well. During the refit Selena painted a picture of a polar bear on the vessel and hung a set of Caribou antlers. The lights shining through the portholes made the boat feel warm and happy.

The NARL is a scientific support facility. Within that NARL support of a whole range of scientific efforts, *Alumiak* was to support bird studies and apply various technologies to get better site-specific profiles of plant and animal life on the bottom and in mid-water column of the Beaufort Sea. During our refit of the *Alumiak* I conferred with biologists and ornithologists from the University of Alaska and other universities around the country to refine tasks for the vessel. We loaded foodstuffs to support the crew, and hired Selena as cook. Finally in late July the ice pack had moved significantly offshore and the time arrived to put to sea. With the crew standing by, scientists got their gear loaded. The engines started and we slowly rotated side to side in reverse: the bow slid off the beach without sinking any lower. Success and the lifting of anxiety felt sweet, indeed.

That summer we worked with Dr. Carter Broad. His bottom-sampling for OCSEAP required being at locations specifically according to his plan. Our problem was a lack of loran navigation aids (we were too high up in the Arctic for accurate loran coverage). Cross triangulation using the radar was our only hope, but the Beaufort coastline lies so low that it is difficult for radar to distinguish the coastline much of the time. The oil companies had installed towers that reflect morse code identifications, but only at irregular intervals. Doing our best to put Dr. Broad on station, we began

taking samples. We were approximately 50 km (30 miles) north of Point Barrow where the Chuckchi and Beaufort Seas come together at the conclusion of Carter's series of stations. Next we headed east. We ducked into bays and wove our way through dense parades of large chunks of floating ice known as "bergie bits." Some days we waited for large pans of ice to move so that we could continue eastward. Other days we pushed against pans of ice to move them ourselves.

Fog is commonly a problem during open water season along the Beaufort coast. Navigating through dense ice fields with only the radar to give direction is a slow and tricky operation. The bird folks wanted to travel in a straight line at a steady velocity for a given amount of time to justify a transect. Transect counts yield a number which represents a "number of birds" seen by a method prescribed for repetitive surveys. This method was nearly impossible, given the fact that ice re-routed us daily. We arrived in Prudhoe Bay. Somewhere along the line we had failed to put enough essentials on board. We were out of toilet paper. Also I failed to take into account that one field assistant was a vegetarian so we needed to take on more produce. Leaving Prudhoe, a storm held us up near Oliktok Point. For three days the wind blew 60 knots. We anchored with *Alumiak*'s large stern anchor, but that presented her broad stern to the waves, which crashed into us continuously. Selena baked a cake for my birthday, and we looked for ways to pass the days. One week later we arrived in Kaktovik near the eastern end of the State of Alaska's segment of the Beaufort Sea. Surrounded by ice, we were in danger of getting locked in. During our trip east we re-supplied several field camps by delivering drums of diesel and 100-pound bottles of propane, which we carried on deck. We met each station and covered each transect. Time to head home.

The *Alumiak* is not fast. Five knots is near her top speed and the homeward trip seemed to take forever, but one day in late September we rounded Pt. Barrow and parked in front of NARL. The *Alumiak* had traveled over 800 km (500 miles) of single line transects; set up on 26 individual stations for bottom- and mid-column- sampling; supported the taking of hundreds of bird and marine samples; placed a 500-pound current meter off Oliktok Point; supported a crew of five and a science support staff of eight for two months—and brought everyone home safely.

With *Alumiak* pulled safely up the beach and gear stowed, we turned our attention to the coming year.

Jacob Adams, Chairman of the Alaska Eskimo Whaling Commission, asked the Lab to help him answer questions from the International Whaling Commission (IWC). An IWC-imposed quota on Barrow whalers threatened to put a moratorium on most or all subsistence whaling. A meeting at the Laboratory attended by the Bureau of Land Management (BLM) resulted in BLM asking the Lab to help them answer the question, "do endangered species bowhead whales inhabit the nearshore proposed lease area in and around Prudhoe Bay"? Dr. Kelley agreed to support scientific investigations to answer whale-related questions. Fortunately, the Operations Department had been working with a Navy Commander, Dr. Bill Ellison, using sonabuys and listening to various sounds under ice, as a learning tool for interactive activities with local high school youth. I was given the position of Acting Director for Operations at about this time. Also during this time we had persuaded the State of Alaska Department of Fish and Game's team of marine mammal biologists under John J. Burns, to purchase a sonar system. We could then use the system with local high school students, to assess the diving habits of passing bowhead whales. High school boys and girls interviewed, and five boys were accepted into the program. A monitoring camp was established on shorefast ice off the coast near Barrow. Because no one had recorded the sounds of a bowhead whale, we first had to determine what sounds a bowhead makes. So we recorded a medley of marine mammal vocalizations from a small tent, using rudimentary equipment. By a process of elimination, we narrowed the sounds (and there were many) to ones that probably represented the bowheads. We watched whales passing near the camp and tried catching the bowhead with the sonar gear. One day the lead closed and a cow and calf bowhead were trapped right in front of us. We recorded, for hours, the sounds of mom communicating with junior. At length we had obtained what we needed to help BLM with their question about whales' using the proposed lease area near Prudhoe Bay.

By agreeing to support the BLM effort, we had committed the *Alumiak* to a busy season in which she could support little additional work. To support additional needs for vessel-based research, we began a project of refurbishing the other NARL ship, the *Natchik* (Fig. 2). The *Natchik* is a wooden hulled, iron bark-protected, single-engine, 32-foot (10-m) vessel. She had been sitting on the beach for some years and as a result of seasons of freeze-drying her timbers, her caulking was not in good shape. For a winter project we had the *Natchik* towed into the "Feco" hangar. There we removed each piece of iron bark that pro-



Fig. 2. The *Natchik*, also refurbished at NARL for nearshore work conducting bioenvironmental studies during the OCSEAP years, showing the deep round hull that challenged the crane operator during the vessel's launching in 1978. BASC Photo, by D. Ramey, January 2000. (See also, Laursen et al., this volume: Fig. 6.)

tected the hull, then recaulked the main hull. It was a jigsaw puzzle of huge proportions. In addition to the hull work, we rebuilt the main diesel and added the ability to generate 110-volt electric power in support of research instruments. We installed a new cook stove, enhanced the living space, and generally made her more seaworthy. While all these chores were being accomplished the NARL staff continued to meet with various agencies to discuss upcoming work. In the spring the *Natchik* was towed back to the beach and readied for launching.

When the ice moved out that year, the *Alumiak* was ready and her movement back into the water seemed almost routine. The fun came with launching the *Natchik*. Because *Natchik* has a round hull we could not drag her upright into the water the way we could the *Alumiak*. Instead, we had to lift her with nylon belts, a lifting bridle and a crane. Given *Natchik*'s considerable weight, the relatively small NARL crane, except when raised almost straight up, was not sufficient to the task. She had to be "bounced" (in a series of pickups and letdowns) toward the water. I was never sure which would happen first: would the *Natchik* reach her floating depth, or the crane its drowning depth first? It was nip and tuck. But, with luck and perseverance she at last floated. We hired a boat captain, Everett Bennett. With his crew on board *Natchik*, and the *Alumiak* alongside, both vessels headed east.

The *Natchik* was primarily assigned to conducting bird transect surveys. We stationed the *Alumiak* inshore of Narwhal Island, midway between Prudhoe Bay and Kaktovik. We set sonabuys offshore on homemade floats, and began listening for bowheads. One day, a polar bear sow with cubs visited the *Alumiak*, creating quite a stir on board. We also had to contend with pans of ice that tended to snag our sonabuoys floats and drag them away, but all in all, the season went smoothly. The project was supported by the NARL Twin Otter, which regularly landed on Narwhal to resupply us and to change out spotter crews. Although we did not hear many whales, we did provide data for potential problems with animal avoidance of harsh sounds being produced by pinging seismic vessels in the whales' migration corridor. Early in September, the research season concluded, so we headed home. One day west of Narwal, *Alumiak* picked up an urgent radio call from the *Natchik* – she had run hard aground and needed our help. We reversed course and steamed back. East of Narwal we found that the *Natchik* had swung at anchor during the night and drifted onto some rocks. We used our small boat to put a cable to her. The light-weight warping tug *Alumiak* then pulled her to safety. Together again, we set course for Barrow.

The *Alumiak* had supported essential early efforts to identify potential problems associated with the migration of an endangered species of whale, resupplied remote camps and performed (with her small boat) some surveys for feeding areas that could be considered as critical feeding areas for migrating whales. The *Natchik* had supported bird studies, along with setting out a number of current meters.

This was the last year that the *Alumiak* and the *Natchik* went to sea. The Department of the Navy had determined that NARL was too costly an operation for the Navy to sponsor alone, and chose to end its stewardship of the Lab. Thus ended a wonderful experience. In 1980 the NARL was turned over to local caretakers (Kelley and Brower, this volume). I stayed on in the community to work with Jacob Adams and the Whaling Commission, to get married and to have a son born in Barrow.

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Key Words: Office of Naval Research, research growth, Navy mission, staff, University of Alaska, aircraft, vessels, field stations, ice stations, in-house research

This map illustrates the Arctic National Wildlife Range in Alaska. The range is situated along the northern coast, bordering the Arctic Ocean to the north, the Chukchi Sea to the northwest, and the Beaufort Sea to the northeast. Key geographical features include the Brooks Range to the south, the Coastal Plain, and the Foothills. Major towns and locations marked include Barrow, Peard Bay, Wainwright, Utqiagvik, and Happy Valley. The map also shows the National Petroleum Reserve Alaska, the Arctic National Wildlife Range, and the Pipeline Haul Road. A scale bar indicates distances up to 200 km. An inset map shows the location of the range within the state of Alaska.

middle tundra north of the 10°C July isotherm. Vegetation patterns and species complexes repeatedly suggest permanent aquatic influences throughout the growing season. Decomposition rates of organic peats are slow, such that a buildup of dead organic material continues, ever since it began some 10 000 years ago with the change in climate regime at the beginning of the Holocene. The accumulating peat blanket acts as a “wick” that supplies a constant source of water during

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the growing season from the increasing depth of thaw that releases melt water from beneath. The zone of annual defrost is termed the “active layer,” the uppermost portion of peat soil fraction that thaws seasonally during the summer growing season. Vegetation patterns also reflect influences imposed by geomorphic and physiographic land features that characterize tundra landscapes.

Paradoxically, the North Slope is classified environmentally as a cold desert because it lies in the rain shadow of the Brooks Range. In this shadow precipitation rarely exceeds 150 mm (~6 inches, water equivalent) at the plateau’s northernmost outpost at Barrow. Differences in local physical and biological character are manifested in high latitude (71° 20’ N). Quaternary geologic history, expressed now as contemporary cool and cloudy summer climate, low windswept relief, multiple landforms (e.g., pingos, polygonally patterned ground, frost heaves, frost boils, mud pots, and rock polygons), thaw ponds and lakes, NW to SE directional lakes dominated by winds out of the ENE (Carson, this volume), organic peat-rich “soils,” and myriad dynamic biotic, abiotic, and geomorphic processes challenge understanding by visitors from the Temperate Zone. All of these underlying conditions, overlain by seasonal cycles, promote instability in a framework of seasonally accelerated geologic energy flux (for additional perspectives on this paradox, see Walker’s two chapters, this volume.)

Prior to the establishment of NARL in 1947, scientific analyses of these and other arctic paradoxes were at best sporadic. ‘Colonial science’ was conducted by non-residents who took the information south. Even excellent work by many visiting scientists faded into “gray” literature’s obscurity as reports placed in file cabinets, and other documents, not readily available to scientific, let alone, to lay communities. This era of ‘colonial science’ also preceded the personal computer’s availability, which has so recently revolutionized the outpouring of information from this and other circumpolar arctic regions. When NARL was founded, science had an arctic anchor: the Arctic Institute of North America, and the Office of Naval Research obligated to publish their results.

The region lacked ‘resident’ researchers and scientific support facilities for year round research. The Department of Defense recognized its operational need to come to terms with the Arctic, once the Navy began exploring Naval Petroleum Reserve No. 4 in 1944, and had to deal with an arctic land area the size of Indiana (Schindler, this volume). Transportation

methods over tundra and sea ice were pioneered. These methods eventually included tracked, balloon-tired, and air cushion vehicles. Oceanographic studies resulted in the mapping of the Barrow Sea Canyon, the continental shelf, and hosting the first submarines to enter the Arctic Basin from the Pacific. Basic studies in sea ice and ice stresses off the coast of Barrow assisted in the design of ice-strengthened drilling platforms later developed in Cook Inlet, and contributed to modifications made to the *USS Manhattan* as it was prepared for its test voyage through the Northwest Passage.

The Office of Naval Research (ONR), established in 1946 by an act of Congress, developed an “oil camp” prior to 1947, from which its Arctic Research Laboratory (ARL) evolved by 1949 (Laursen, 1976). By 1952, ONR was supporting Navy-funded science at its new Arctic Research Laboratory (ARL) facility made up mostly of Quonset hut buildings (Reed and Ronhovde, 1971). The Navy-owned research facility was operated by a succession of contractors, and ultimately by the University of Alaska, which assumed administrative responsibility for science in 1953. The Lab ultimately became the Naval Arctic Research Laboratory (NARL) and developed an official logo (Fig. 2). Full operational, maintenance and scientific support responsibilities were assumed by the University of Alaska in 1976, with an annual contract cost that grew to \$11.5 million by 1979.



Fig. 2. The official logo and seal developed by the NARL was adopted while developing plans for constructing the new laboratory building.

The mission of the NARL was to provide all facilities and services for accommodating and accomplishing programs of basic and applied research that contributed to successful Navy operations in US arctic regions and environments (Laursen, 1976, 1977 a & b, 1979, 1980; Laursen and Hall, 1979, 1980; Laursen and Kelley, 1979; Laursen and Selby, 1979 a & b). The main H-shaped laboratory (Building # 250-251) was added to the facility by the early 1950s, but scientific growth pressured the need for newer support facilities for which the “new” lab was constructed in 1968-1969, one of the first built on pilings to prevent thawing of the permafrost beneath its gravel pad. The NARL Camp on its 4 500-acre tract grew to house 191 buildings and structures (Fig. 3), built a 5 000-foot lighted runway and constructed two hangar facilities to accommodate C130 aircraft. Although built originally to house the C130 aircraft, these hangars ultimately housed all eight NARL aircraft, two DC3’s, one super C117D, four Cessna 180’s, a DeHaviland twin otter (Fig. 4) and two leased aircraft, a DeHaviland single-engined Otter and a Maul. In 1976, these aircraft logged over 2 600 flight hours (Laursen, 1976). The air safety record was excellent; only one C180 actually crashed. That mishap occurred on the NARL runway and was due to severe crosswinds (Fig. 5). Nobody was injured.



Fig. 3. The NARL as it appeared in 1978 with its full compliment of 191 buildings and structures used in support of Arctic research with its relatively new “H” shaped laboratory building. (A Tom Albert Photo, Visiting Scientist to the Animal Research Facility).

Ship operations, using a number of Boston Whalers, expanded in time of need to incorporate larger vessel platforms such as the *R/V Natchik* (Fig. 6), and the *R/V Alumiak*, (Fig. 7) during the OCSEAP years (Dronenburg, this volume). These vessels were used to support distant marine and terrestrial biological investigations.



Fig. 4. The NARL fleet of aircraft in part: DC 3’s, C 117 D’s, Cessna 180’s, and a Twin Otter.



Fig. 5. The only NARL aircraft (Cessna 180) to flip-crash on site. Assistant Director for Science, Laursen, and wife Beth are pictured.



Fig. 6. The Research/Vessel Natchik, a converted fishing vessel with a tendency to “rock & roll”.

Over the Navy-administered part of its lifespan, this Laboratory fulfilled mission-oriented Navy research initially, then provided research support funded by many non-Navy federal, state, and local agencies (AIBS Reports, 1977; Manson and Sater, 1969; Reed, 1969; Reed and Ronhovde, 1971). Research efforts sup-



Fig. 7. A converted, double outboard driven harbor tender became the Research/Vessel Alumiak (for alum-inum um-iak), which worked well in shallow Arctic coastal shoals but took stormy seas poorly.

ported investigations primarily in areas of oceanography, meteorology, underwater acoustics, geophysics, atmospheric physics, aquatic marine biology (Fig. 8), aerial, atmospheric, and terrestrial biology. Through operation of this flagship facility, the NARL, its 14 terrestrial field support stations (Fig. 9)-some of which were located in the most pristine environments such as those found at Anaktuvuk Pass (Fig. 10), Atqasuk on



Fig. 8. The research team member of Ron Atlas' marine biological investigations into the degradation of crude oil in the shallow benthos of the Arctic's continental shelf.



Fig. 9. Locations of 14 primary NARL Terrestrial Field Camps that supported facilities and shelters for research and used year round.



Fig. 10. The Anaktuvuk Pass NARL Field site wannigan.

the Meade River (Fig. 11), Noluk Lake (Fig. 12), and Peters Lake (Fig. 13), permanently drifting ice islands (T-3, Fletcher's Ice Island and the ARLIS series), temporary (seasonal) ice pack stations (AIDJEX) (Fig. 14), airborne platforms, satellite remote sensing, and other facilities, furnished scientists from around the world with means for conducting high altitude and high latitude arctic research.

The NARL grew to become the world's largest facility for the support of all forms of arctic research. By 1976 it had provided services to over 30 different agencies, 65 colleges, universities, private and public research institutions, and some 700 scientists, graduate students, and technicians. By 1979, the number of scientific users grew to over 2 700 person-days annually. It was, until its closure in 1980, the only coastal logistics support base of its kind in the Arctic that the US Federal Government actively maintained operationally throughout the year (Frosch, 1969; Manson and Sater, 1969; Reed, 1969; Reed and Ronhovde, 1971). Several northern countries with high latitude arctic tundra within their own national borders did, and some still do, maintain similar research stations in



Fig. 11. The Meade River NARL field research camp 100 km south of Barrow near the river village of Atqasuk on the Coastal Plains Province.



Fig. 12. The NARL field site and buildings at Noluk Lake in the Foothills Province of the DeLong Mountains, western Brooks Range, where a C47 still rests on lake bottom just offshore of the camp.

concept to the NARL, but they are smaller and are operated seasonally (Laursen & Kelley, 1979).

Whereas other chapters in this volume portray turning points in the institutional history of the Laboratory, this account emphasizes the Lab's growth and diversified activities up to its final days as a Naval facility.

SOURCES OF INFORMATION

Information was gleaned from various literature sources on the ARL/NARL for the period 1947 to 1965, from peer-reviewed journal literature (1967-1998), from annual technical, programmatic, and in-house reports made to funding agencies, from the senior author's experiences as a graduate student conducting thesis research (1971-1976) at the NARL (Laursen, 1975), from his experiences first as the NARL Assistant Director for Science (1976-1980), then as acting Assistant Director for Administration, as



Fig. 13. The NARL's field site complex on Peters Lake in the east-central Brooks Mountain Province.



Fig. 14. The NARL Twin Otter on the sea ice landing strip of the AIDJEX research project.

acting Assistant Director for Operations, and as Acting Technical Director (1996-1997), positions often held simultaneously, and finally from the second author's experiences as NARL's Technical Director (1977-1980) and as a veteran arctic researcher. Photographs are by the senior author unless otherwise noted. Early history of the ARL/NARL from 1944 to 1969 is provided in Monson and Sater (1969).

DEVELOPMENTAL STAGES

The Office of Naval Research (ONR) was directed by Congress in 1946 to execute two primary missions: 1) to encourage, plan, promote, initiate, and coordinate a program of naval mission oriented research, and 2) to conduct a research program to augment those conducted by other elements of the Navy (Owen, 1969). Owned by the US Navy, but operated under contract to the DOD, the University of Alaska played a significant role in the development of the laboratory. The ONR traditionally operated the NARL as a national, if not an international research site and support facility. As utilized, the NARL provided information

and support to many government agencies for their own project work. A basic feasibility study conducted at the ARL in Project Lincoln, demonstrated the need and capabilities of what became the Distant Early Warning (DEW) line. It was Kobayasi et al. in 1965 who made the first “mycological pilgrimage” to Arctic Alaska and then published the results of that work, wherein they listed 203 taxa (six of which were new to science) in 136 genera representing 61 families of fungi and one Myxomycete, *Lycogola epidendrum* (L.) Fries (Kobayasi et al., 1967). Later, an additional 97 taxa in 57 genera from 30 families completed the workup of collections made in 1965 (Kobayasi et al., 1969). Higher fungi specific to Northern Alaska are reported elsewhere (Laursen et al., this volume).

Exploration of Naval Petroleum Reserve No. 4 (PET4) terminated in 1953 (Fig. 15). With the 1969 oil “re-discovery,” and the completion of the new and modern NARL lab building that same year, interest in Arctic environment research was peaking. Prior to 1969, the NARL had primarily provided a base for transient scientists, many of whom came during the spring, summer, and fall months (March–October). By 1970, the Laboratory’s permanent staff of about 130 was developing “in-house” research projects that continued throughout the year. Staff size later grew to over 220 year round employees, a complement that would swell to 320 during peak season. This shift became an important programmatic move toward extending the NARL’s mission by providing opportunities to carry out studies in the dead of winter and to distribute an increasing workload more evenly throughout the laboratory staff over the entire fiscal year. During the late 70s, the number of permanent staff ballooned to assist the greatly increased load of inves-

tigators for all seasons. Interagency service agreements were developed with the Aerospace Defense Command, the Federal Aviation Administration, the National Oceanographic and Atmospheric Administration, the Naval Petroleum and Oil Shale Reserves, the State of Alaska, the US Coast Guard, and the Public Health Service, as well as with other corporate and university research interests.

From 1969 to 1974, the International Biological Tundra Biome Programme (IBP-TB) involved many investigators, degree seeking students (Brown, this volume), and technical staff assisting these efforts. In 1974, Man and the Biosphere (MAB) began to influence NARL’s support activities, but to a much less extent than it did during the IBP-TB. By 1976, Research on Arctic Tundra Environments (RATE) (Fig. 16) was underway with 19 different projects, 10 of which used the NARL’s Meade River field station 100 km (60 miles) south of Barrow near Atqasuk as its primary epicenter for activity and study. Like the IBP-TB and MAB programs, RATE projects were financially supported by the National Science Foundation.



Fig. 15. Naval Petroleum Reserve #4, Well Site 4, near Umiat on the Colville River in the Foothills Province of the Arctic North Slope, where research on oiled tundra contamination studies were conducted by Dr. Kaye Everett (deceased), the senior author, and others.



Fig. 16. Research on Arctic Tundra Environments (RATE) was initiated with 19 different projects, 10 of which worked out of the Meade River NARL field site. Pictured are two students with principal investigators Terry Chapin (L) and Gius Shaver (R).

The large Arctic Ice Dynamics Joint Experiment (AIDJEX), a US-Canadian cooperative consisting of 20 research programs needing over 900 tons of supplies aimed at advancing our understanding of large-scale response of sea ice to environmental parameters, occurred simultaneously (Weeks, this volume). The AIDJEX project was large and taxed the support ability of the NARL to provide everything needed, but it did so for 266 investigators who accumulated over

16 000 person-days of research effort. A successor to AIDJEX was the Outer Continental Shelf Environmental Assessment Program (OCSEAP) funded by the Bureau of Land Management (BLM). This program was responsible for gathering bioenvironmental information in anticipation of the environmental impact of industry on the area three miles offshore within the US Beaufort Sea. Assessed were both the marine environment within the 200-m continental shelf contour and the interfacing terrestrial environment. Initial funding of ca. \$24 million for 1.5 years funded 40 different research programs. Most lasted for three to five years.

The Energy Resource Development Administration (ERDA), now the Department of Energy, also funded several projects investigating energy related terrestrial problems in their Rates, Response, Resilience, and Recovery (R₄D) research efforts (Fig. 17) (Laursen, Post Doctoral studies, 1975-6; Schaus, R.H. 1976). Other in-house research was contained through Project Whales, research funded by BLM that led to the revolution of looking seriously into the biology of the Bowhead (Fig. 18) and Gray whales that frequented the shallow waters off Alaskan coasts of the Chukchi and Beaufort Seas (Kelley and Laursen, 1979 a, b, & c). While these multi-investigator, multi-discipline, and often massively funded programs were ongoing, the Navy's own 40 different research efforts were beginning to wane. As many as 45 other non-DOD and smaller projects were also taking place, and kept the "hum of activity" at a feverish but acceptable level.

Since its inception, the ONR supported research projects covering a broad spectrum of topics vital to increasing our understanding of Arctic phenomena



Fig. 17. Department of Energy funded projects investigated energy related terrestrial problems in their Rates, Response, Resilience, and Recovery (R₄D) research efforts. Pictured are Pete Linkins and Kaye Everett applying Prudhoe crude oil to assess its effects on microbial communities and peat soil structure.



Fig. 18. In-house research Project Whales, funded by BLM, led to greater understanding of the reproductive biology of the Bowhead whale (fetus shown), which directly influenced the IWC to permit the resumption of bowhead whale hunting in traditional subsistence style.

(e.g., atmospheric pollutants; radionuclide/food chain interactions; beach erosion; sea ice/atmosphere interactions; forces in sea ice; the marginal ice zone; marine productivity under sea ice; thermoregulation and comparative mechanisms of adaptation; blood chemistries; thermogenesis in arctic fauna; plant physiology; the taxonomy of myriad organisms; patterns in migratory fauna, especially in bird populations; etc.)

One Navy program in particular kept growing. This was the research conducted at the Animal Research Facility (ARF) (Figs 19-22), a program that employed eight full-time staff, a veterinarian (Fig. 23), and supported post doctoral (Fig. 24), and visiting scientist (Fig. 25) programs (Philo et al., this volume). ARF research ultimately became a major in-house, year round research effort. Specific areas of research interest included metabolic and cardiovascular responses to cold, hematology, body water and electrolyte regulation, radio telemetry (tracking), hibernation triggers, and the thermoregulatory mechanisms of adaptation and acclimatization. Most specimens utilized in these studies were captured from arctic terrestrial, aquatic and marine habitats.

The ARF provided opportunities to study Alaskan native species *in situ* or in modern, well-equipped laboratories. Most species used were taken from local environments, maintained by providing them with natural foodstuffs, provided the best of veterinarian and animal care, provided ambient as well as interior living quarters when best suited to the research or surgery being conducted, then released back into their natural environment when research was completed. Oddly enough, some of the larger animals (wolves) when released 130 miles (200km) to the south, several



Fig. 19. The NARL in part during early spring, showing the Animal Research Facility (ARF) complex of 63 buildings and research support structures lying under and to both sides of the main utilidor coming from the new power plant.

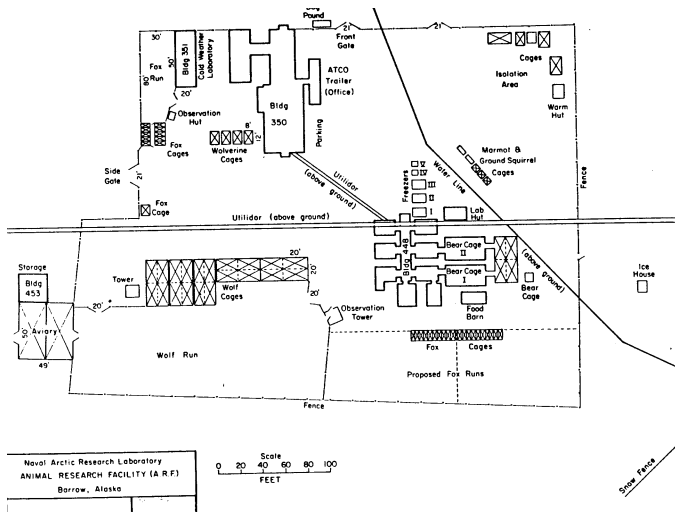


Fig. 20. A schematic of the whole ARF compound of 63 buildings and research support structures lying under and to both sides of the main utilidor (midline) coming from the new power plant.

animals found their way back to the lab to “rejoin” the staff. As many as 60 wolves were housed at one time, but the resident population was generally maintained at or near 18. If release back into the wild was not feasible, animals would be contributed to major zoos around the country. Irish the polar bear (Fig. 26) earned the farthest relocation transport from Barrow, when the Providence RI Zoo took him. Complete clinical records provided the researcher with valuable baseline vital statistics on each research subject. Parameters such as feeding regimens, monthly body weights, quarterly blood chemistries, hematological data, detailed history of the animals use in research and surgery, complete medical health records, and repro-

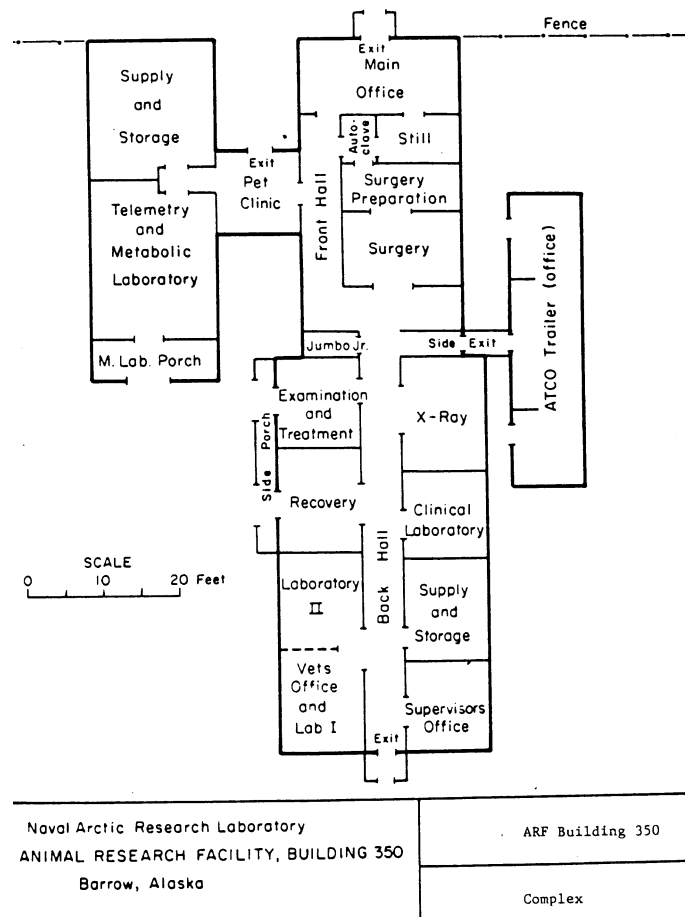


Fig. 21. A schematic of the Animal Research Facility (ARF) Building 350 complex housing the technical research and maintenance laboratories.

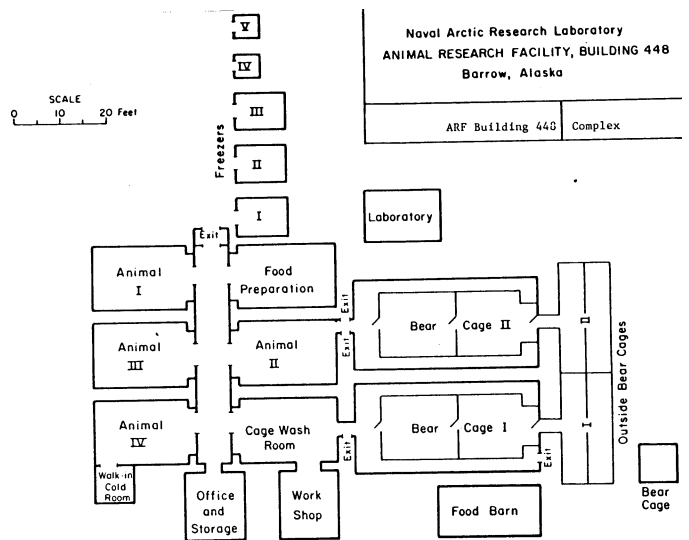


Fig. 22. A schematic of the Animal Research Facility (ARF) Building 448 complex housing animal research, care, and maintenance facilities.



Fig. 23. the Animal Research Facility (ARF) veterinarian of many years, Dr. Michael Philo, attending to the needs of a resident wolf.



Fig. 24. The Animal Research Facility (ARF) hosted the first in-house Post Doctoral Program funded by the Office of Naval Research (ONR). Its first resident was Dr. Tim Casey and his wife, followed by Dr. Mark Chappell. Dr. Erich Follmann (pictured) was the longest to reside before joining the Institute of Arctic Biology at the University of Alaska Fairbanks.



Fig. 25. The Animal Research Facility (ARF) also hosted the first in-house Visiting Scientist Program, which was also funded by the Office of Naval Research (ONR). Dr. Tom Albert was its only visiting scientist (1977-1979) prior to the departure of the Navy, but still resides in Barrow.

ductive statistics were maintained. During FY 79, the ARF supported 15 research projects, logged over 13 600 person-hours (equaling 1701 man days) of support by ARF's eight full-time staff, two resident Post Doctoral students, a full-time veterinarian, and a Visiting Scientist. Twenty-four publications came from these "in-house" research efforts at the ARF that year, a truly viable program in animal care, maintenance, and research (Laursen and Selby, 1979b).

During the three-year period, 1977-1979, an educational effort was established to offer training opportunities for local community members. Five courses were developed and initiated from needs that the community expressed for services. Training programs emphasized: Water Treatment in Arctic Environments, and plant operation; Introduction to Library Services: A Training Program for Library Technicians, library science for local schools; Arctic geology: Alternate Energy and Mineral Resources; Marine Mammal Bioacoustics, with shipboard training; and Arctic Mammalogy: Biology, Physiology, Care and Maintenance Training (Laursen, 1980; Laursen and Craig, 1980; Laursen and Eley, 1980; Laursen and Harland,



Fig. 26. The Animal Research Facility (ARF) housed up to three polar bears at one time in support of myriad research projects. Pictured is Irish, its long time resident, born, and raised at the NARL, and who, upon the ARF's closure, was sent to the Providence RI Zoo.

1980; Laursen and Linkins, 1980). The funding for these well-attended courses was provided by the Department of Labor through the Alaska Federation of Natives' CETA program.

The last multi-investigator effort and meeting of professional scientists to take place at NARL was the ONR/NSF sponsored First International Symposium on Arcto-Alpine Mycology (FISAM), held 16-24 August 1980 (Laursen and Ammirati, 1982b; Laursen and Kelley, 1982). The purpose of holding this international meeting of mycologists working on fungal problems from circumpolar arctic and alpine tundra was to: 1) ascertain the state of mycological studies in these environments; 2) bring together current workers in the field to hone the level of understanding worldwide; and 3) to develop future research planning and international cooperative studies and exchange programs. The theme of the meeting, therefore, was focused on circumpolar habit and habitat variation, distribution, taxonomic relationships, systematics of fungi, functions of the fungi in cold-dominated regions, and

adaptive radiation of fungal species into high latitude and altitude habitats. The proceedings of the FISAM was published (Laursen and Ammirati, 1982a). To date, there have been four additional ISAM meetings, one held every four years. After Barrow's first historic meeting, others have been conducted in Switzerland (1984), France (1988), Norway (Svalbard) (1992), and Russia (1996).

THE NAVY'S DEPARTURE

Growth and diversification of research efforts in the North forced the ONR to review its NARL mission for the future. The Navy had been attempting to reduce NARL costs since 1972, when it assigned its first full-time Commanding Officer to work alongside the University of Alaska's science support staff, and the Operations and Maintenance staff. A plan for reducing the level of NARL operations was presented by ONR representatives to the University of Alaska in early August of 1979. This plan called for:

- 1) continuing support of DOD research and, on a limited reimbursable basis, non-DOD sponsored research, which had become 87 percent of the research being conducted by late 1979 and early 1980;
- 2) reducing the cost of NARL operation from \$11.5 million to \$6.7 million annually, most of which were operation and maintenance (O & M) costs;
- 3) reducing the requirement for facility maintenance and eliminate the science fabrication shops; thus, setting out on a site cleanup and old building demolition course;
- 4) terminating ship operations, unless the research project needing these services assumed full costs;
- 5) reducing the vehicle pool and vehicle maintenance;
- 6) discontinuing library services, resulting mostly from shifting space needs;
- 7) intensifying property disposal and consolidation and reduce housing units and work space;
- 8) reducing the ARF to caretaker status by transferring animals to other institutions (Kelley, 1979).

A new NARL "host" was sought: an agency or consortium of agencies willing to assume their "fair share" of all O & M costs to run and maintain aging facilities. None were identified. The NARL was closed to Navy-supported science in October of 1980. A five-year plan for transfer of the NARL to the Barrow village corporation (UIC—Kelley and Brower, this

volume) was put into place. The Laboratory complex was reduced to some 46 buildings from its peak of 191, and streamlined in operations.

CONCLUSIONS

Originally, responsibility for arctic research belonged to the Navy. Increasing numbers of agencies besides ONR began funding projects of all sizes. Research conducted during the early years (1947-1954) was developmental; that conducted during the golden years (1955-1970) was cutting edge; and that conducted during the multi-investigator, multi-discipline big project era (1970-1979) was dubbed the mega-project period, which taxed the Laboratory's aging physical plant.

During the Navy's 33-year tenure, a research facility was clearly shown to be essential to arctic research efforts. A growing need was recognized for setting aside ecological reserves for supporting long-term research efforts. Mutual international concerns, and facilitation of information flow among researchers had also been clearly identified.

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APPENDIX

Naval Commanding Officers

Other contributions to this volume mention one or another of the resident Naval Commanding Officers at NARL. Since this contribution addresses the period (1972-1980) in which the Navy stationed a full-time Base Commander at the NARL Camp, the authors made a partially successful attempt to develop a list of the individuals who served in that capacity. We cannot guarantee the accuracy of this list, and are unsure of actual dates of service. In order of service, beginning in 1972, the Naval Commanders were: Robert Vollmer, Brian Shoemaker, Bud Burnhardt, Richard Schaus, Dennis Christian, Mike Brown, and Maria Kazanowska.

History of the NARL Animal Research Facility (ARF) and its Contribution to the Development of a Rabies Control Program for the North Slope

Mike Philo¹, Larry Underwood², and Art Callahan³

ABSTRACT: The Animal Research Facility (ARF) at NARL in Barrow provided unique opportunities to conduct simultaneous laboratory and field studies of birds and mammals under arctic conditions. Its growth, contributions, and the transfer of its functions to the community of Alaska's North Slope are outlined.

Key words: arctic animals, environmental physiology, virology, rabies, veterinary services

FROM ANIMAL COLONY TO ANIMAL RESEARCH FACILITY

The Animal Colony, as it was known in the early days, started modestly enough with brown lemmings, arctic ground squirrels and arctic foxes. The first large mammals were a litter of wolf pups caught in the Anaktuvuk Pass area. "Irish" and "Snowflake," two orphaned polar bear cubs, arrived in 1961. Throughout the 1960s and early 1970s, the colony grew. Most large mammals came to the facility as orphaned and/or injured individuals. Several wolverines were sent to the Lab by the Royal Canadian Mounted Police, who were required to trap them in the Yukon Territory. Any wolverines they found alive in leg-hold traps were shipped to the Lab.

Medium-sized and small mammals were obtained, usually from residents of the region, whenever particular research projects required. Children throughout the region were paid \$1 to \$5 each for brown or collared lemmings whenever researchers needed them. In addition, the lab maintained a brown lemming colony more or less continuously from its earliest days. Inupiat trappers and lab personnel live trapped Arctic foxes, weasels and snowy owls for specific research projects. Typically, these animals were released when the projects ended.

NARL provided caging, food and care for the animals. Veterinary care was often provided by visiting researchers when needed. In emergency situations, veterinarians were brought in from Fairbanks. For

many years, an excellent staff of resident caretakers was headed by Mr. Pete Sovalik (Henshaw and Brewer, this volume). In addition to his leadership, Pete provided excellent advice, suggestions and background wisdom to a generation of graduate students and principal investigators working at the facility. The caretaker staff also served as laboratory technicians and field assistants, as needed.

Research conducted at the Laboratory contributed significantly to our understanding of how animals adapt to, and tolerate chronically low ambient temperatures. Studies conducted at the Animal Colony included:

- Dr. Jim Gessaman - Energy Balance in the Snowy Owl
- Dr. Ed Folk - Environmental Physiology in Large Arctic Mammals
- Dr. Bob Henshaw - Circulation in Cold Stressed Canids and Wolverines (Henshaw, this volume)
- Dr. Larry Underwood - Seasonal Energy Balance in Arctic Foxes various investigators - Studies of brown lemming physiology and behavior

By the early 1970s, the Animal Colony was supporting over 100 large and medium-sized mammals, and dozens of small mammals and birds. Funding for the facility was *ad hoc* at best until it became a line item in NARL's budget in 1974. Although the NARL had excellent facilities for small animals, the facilities for

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larger mammals at that time were inadequate. Investigators had to work under less than ideal conditions. The inconveniences included crowded and widely dispersed holding facilities and equipment, less than adequate examining and experimental areas, a poor sanitary environment, and, above all lack of a full-time resident veterinarian.

In 1974, efforts were initiated to upgrade the Animal Research facility. Several expert consultants, including Dr. Ted Reed, Director of the Smithsonian Institution National Zoo, and Dr. Tom Albert of the University of Maryland School of Veterinary Medicine were brought in to evaluate the current facility and to provide recommendations for improvements.

Dr. Art Callahan, Program Director, Office of Naval Research, and Dr. Larry Underwood, NARL's Assistant Director for Science, planned and implemented the improvements. The U.S. Army Veterinary Corps agreed to assign a permanent veterinary officer, Capt. Mike Philo to NARL to participate in the improvements.

Actual work on the improved large animal facility commenced in 1975, under the direction of Drs. Callahan, Underwood and Philo. The ARF upgrade was based on standards described in the Guide for Care and Use of Laboratory Animals. Building 350, the primary research laboratory building, was enlarged to provide functional areas described in the Guide. The changes made to Building 350 provided a dedicated surgery room, surgery preparation rooms, a postsurgical recovery room, treatment areas, an x-ray room (including film processing), storage, laboratories and offices (see Laursen et al., this volume). A separate small building was placed in the ARF compound in which to isolate new animals or rabies suspects. Ramp facilities were provided for easy transportation of large animals into and out of the new research facility. A large fenced outdoor compound was constructed to provide spacious exercise areas for wolf packs. Additionally, a second large high security compound was created for "Irish," the resident polar bear. A new animal transport cage was developed by Dr. Ed Folk to facilitate transporting large animals from the holding cages into the research building. Heated water dispensers were developed by Derek Craighead to provide liquid water to wolf cages during the winter months. The development and success of the large animal facility is, in large part, due to the dedication and contributions of the many researchers who used the facility.

As required in the Guide, NARL instituted an Animal Care and Use Committee to review all proposed research at the ARF. The purpose of these reviews was to ensure the humane treatment of research animals and that the appropriate species were available for the proposed research. Humane treatment required that all animals receive proper veterinary care, including administration of appropriate drugs to alleviate pain and suffering when appropriate.

Studies conducted at the ARF during the mid- to late 1970s included:

- Dr. Jack Lentfer - Testing Telemetry Devices for Polar Bears
- Dr. Tom Albert - Hibernation Studies in Groundhogs
- Dr. Ted Malinin and Dr. Art Callahan - Hematological Studies in Various Arctic Species
- Dr. James Mosher - Arctic raptor studies
- Mr. Derek Craighead - research on arctic birds and Golden Eagles

RABIES CONTROL AND COMMUNITY VETERINARY SERVICES

Communities of the North Slope Borough soon benefited tangibly from the Animal Research Facility upgrade through development of region-wide rabies control and other programs. Beginning in the winter of 1974-1975 the upgrade made available a full time, resident, U.S. Army veterinarian, Dr. Mike Philo, along with greatly improved veterinary medical and surgical facilities and additional full-time staff.

In addition to the research and research support conducted at the ARF, the staff dedicated time each week to community veterinary services. These services consisted of veterinary clinics to vaccinate, examine and treat private pets along with a program to spay and neuter dogs and cats. The ARF isolation facility was used to hold rabies-suspect animals for observation and the ARF physical facilities were used to package animal heads for shipment to the State's Virology and Rabies Diagnostic Laboratory in Fairbanks.

The North Slope has a history of periodic rabies outbreaks, one of which occurred during the winter of 1976-77. NARL, the U.S. Army, the State of Alaska, and NSB communities worked together to implement a preventive medicine program that consisted of vac-

cinating dogs and cats in the villages. NARL provided supplies and staff support in Barrow. The Army supplied Dr. Philo's services. The State sent rabies vaccine and continued to provide rabies diagnostic support at the State Virology Laboratory. The local NSB communities provided on-site facilities and logistic support, and Arctic Guides in Barrow supplied air taxi service at no charge. That winter, several hundred domestic dogs and cats were vaccinated in Barrow, Wainwright, Nuiqsut and Kaktovik.

The veterinary services provided at the ARF eventually evolved into the NSB veterinary service and public health program under Dr. Les Dalton, who left the

Army to become the Borough's first resident veterinarian. The NSB Department of Health and Social Services' Veterinary Clinic and Public Health Office now provide a full-time, full-service veterinary clinic and a public health program that includes animal control, water testing, sanitary inspections and liaison with the State public health program.

Building # 350, and the ARF facilities themselves became the "Arctic Research Facility" within the North Slope Borough's Department of Wildlife Management. Quakenbush (this volume) describes the continuing scientific uses of the facility.

The NARL and its Transition to the Local Community

John J. Kelley¹ and Arnold Brower, Sr.²

ABSTRACT. The Naval Arctic Research Laboratory's (NARL) fortunes over its history, and even its inauguration in 1947, seemed prone to episodic revisions of national needs and missions. During the 1970s the Navy's mission had shifted its geographic interest elsewhere in the Arctic. Closure seemed imminent in 1974. The University of Alaska operated the NARL for the Office of Naval Research since 1954 and conducted a series of meetings to determine the best way to continue the support of science on the North Slope. No new federal or state host for the NARL could be found; however, the Ukepeagvik Inupiat Corporation (UIC) sought the NARL property to meet community needs during a period of rapid development and expansion. Transfer of the NARL occurred on June 14, 1989. During the 1980s and 1990s the UIC-NARL was host to a number of agencies, commercial companies and a college. The UIC-NARL now can meet the needs of different types of users, including the scientific and engineering community as well as the people of Barrow.

Key words: Alaska Eskimo Whaling Commission (AEWC), animal research facility, Barrow Arctic Science Consortium (BASC), college, Navy, North Slope Borough, Ukepeagvik Inupiat Corporation (UIC), wildlife management.

INTRODUCTION

Their feelings and thoughts can only be surmised, as those first seven scientists led by Professor Laurence Irving stepped out the C-46 aircraft into the warm August day at Barrow, Alaska, in 1947. Perhaps not appreciated by them at the time, this little group of scientists formed the nucleus of the Arctic Research Laboratory, later (1967) renamed the Naval Arctic Research Laboratory (NARL), and finally, after its transition to the community, designated the UIC-NARL. From that August day fifty years ago, scientific research activities involved the people of the local community in increasingly diverse capacities.

Within months of the end of World War II in 1945, the stage was set for greatly expanded arctic research. Besides strictly military related sciences, U. S. interests in the Arctic extended to multidisciplinary research in the natural and social sciences, and to international interactions. The Arctic Institute of North America (AINA) was to play a significant role in working with the Office of Naval Research (USN/ONR) in the management of research projects in the Arctic (Reed and Ronhovde, 1971). The University of Alaska assumed operational responsibility for the ARL in 1954 and continued in that capacity until the end of 1980, when the NARL ceased to be a Navy laboratory.

NARL's fortunes over the years, and even its very inauguration in 1947 seemed prone to episodic revisions of national needs and missions. Upheavals and

changes in priorities aside, the Navy and its contractors long remained committed to the institution. The importance of a research facility on the north coast of Alaska was emphasized by the Navy on the occasion of the dedication of the new laboratory (Building #360, 1969). As Assistant Secretary of the Navy, Robert Frosch, stated, "Probably nothing has contributed so much to the growth of Arctic research in the United States as the simple existence of a laboratory which can and does attract users" (Frosch, 1969:358).

John F. Schindler, Director of the NARL at that time, made what turned out to be prophetic observations for how NARL was to develop during its second quarter-century:

Since the first summer of the laboratory's operation, we have enjoyed a unique relationship with the Natives of Barrow. For most of the lifetime of the laboratory, about 60 percent of our employees have been hired locally. The difficulties that someone from the "South 48" can have trying to accomplish the simplest of chores in an arctic winter can only be appreciated fully by those who have learned the hard way. The people of Barrow have brought experience and knowledge to the laboratory, and the value of these to the research effort can never be fully measured. Many overland trips, ice projects, boat projects, and ice stations owe their success to the presence and gentle suggestions of the local people. I now publicly

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express both my gratitude and the Laboratory's gratitude to the people of Barrow.
(Schindler, 1973:219)

FACTORS AND STEPS IN THE NAVY'S DEPARTURE

By the early 1970s it was evident that the Navy's mission had shifted its geographic interest elsewhere. Moreover, use of the NARL had diversified to supporting such a spectrum of other agencies, both national and international, that the Navy found it difficult to justify sole fiscal responsibility for the laboratory. The Navy's first notice of closure of the laboratory came in 1974 (Kelley 1981), but its execution was stayed by a new national priority assigned to Project (energy) Independence. NARL was thus called upon to support the Department of Interior's Bureau of Land Management (DOI/BLM) Outer Continental Shelf studies, and the National Oceanographic and Atmospheric Administration Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP) Dronenburg; Norton and Weller, this volume). The Biophysics Program Office of the Office of Naval Research meanwhile authorized a new project at the NARL resulting in further development of the Animal Research Facility (ARF—Philo et al., this volume). At that time, nobody foresaw the extent to which this expanded ARF was to play a significant role in the affairs of the Barrow community, when subsistence use of the bowhead whale was threatened by international regulations (Albert; Quakenbush, this volume).

During 1977 the Navy again notified the NARL and its contractors that, unless a new host could be found, the Laboratory would close. Throughout the 30-year history of the NARL to that point, ONR and the USAF had heavily subsidized costs to users. Now the Navy was ordering that all projects be fully cost-recovered by 1978. Use of the lab dropped as user fees rose. NARL went into caretaker status in 1980. The President of the University of Alaska, Dr. Jay Barton, empanelled a task force on the future of the NARL, which also examined alternative support sites. This task force was unable to arrive at an effective solution for keeping the nation's premiere arctic research laboratory in full operation (Kelley, 1981; 1993).

DEVELOPMENTS LEADING TO LOCAL CONTROL

The early 1970s had ushered in important social and political changes for residents of Alaska's North Slope. Congressional passage of the Alaska Native Claims

Settlement Act (ANSCA) in late 1971 promised to reward more than a century of endeavor by the Native people of Alaska to resolve longstanding issues of property ownership and control over resources. The Prudhoe Bay oil fields also began production in 1977. ANSCA provided for the establishment of Native-owned regional corporations and associated village corporations. Ukpeagvik Iñupiat Corporation (UIC, the Barrow Village Corporation) became the local corporate entity closest to, and most interested in, the fate of the NARL assets. Despite attempts to find a new sponsor noted above, no federal or state host could be found to replace the Navy's support of the laboratory.

The Barrow community, meanwhile, experienced rapid development and expansion in the 1970s and 1980s, generating increased needs for both suitable land and housing. Ronald Brower, Sr., recognized the importance of property at NARL to the future expansion of the community. The UIC began inquiring into the transfer of the NARL in 1978.

In 1979 Arnold Brower, Sr., President of the UIC, wrote to Keith Mather, Vice Chancellor for Research at the University of Alaska, expressing UIC's interest in becoming the new host for the NARL. The initial intent was to exchange lands, acre for acre, under ANSCA's 22f exchange provision. The Navy and the Bureau of Land Management (BLM) rejected the initial proposal in 1983. In 1985 a caretaker agreement for the NARL facility was negotiated, but by then, deterioration of many parts of the facility threatened to make it a costly arrangement to UIC or any other caretaker agency. Senator Ted Stevens (Alaska) assisted in completing the negotiation of a transfer agreement in 1986. Some Congressional skepticism greeted the agreement, because previous transfers of nine military bases to civilian entities, some of them Native corporations, had met with financial disaster. In addition, many environmental problems (e.g., suspected radioactive materials, PCBs, oil spills, etc.) plagued the land on which the NARL camp was located. An amended agreement was completed in 1988, which protected UIC from accepting an unknown, but potentially huge, burden of liability. UIC signed the final transfer of the NARL on 14th June 1989 (Fig. 1). Thus the Navy and the BLM at length had been persuaded to yield control and ownership of NARL to local enterprise.



Fig. 1. Transfer of the NARL from the Navy to the UIC, accomplished 14th June 1989. At the signing ceremony, held in the Bureau of Land Management's Statewide Director's offices are (left to right): Back Row: David Case, Alice Solomon, Debbie Suvlu, Maggie Ahmaogak, and Mike Penfold (BLM State Director; Front Row: Max Ahgeak, Arnold Brower, Sr., Ronald Brower, Sr., and Delbert Rexford.

TRANSITION OF NARL TO A LOCAL MULTIPLE-USE FACILITY

When, at the end of the 1980s, the facility was finally transferred to the Ukpeagvik Iñupiat Corporation and operated as the UIC-NARL, the NARL camp formally became a multiple use facility. Transfer of the NARL promised greater flexibility to develop its assets for the good of the community. It became dedicated to the support of four types of research. Examples follow of how some of these uses have developed.

GOVERNMENTAL FUNCTIONS AND NARL

In the last decade of the Navy's tenure, the Animal Research Facility at the NARL included a resident veterinarian and an Army officer (Capt. L. Michael Philo, and Later Capt. Les Dalton). The veterinarians' presence was beneficial also to the Barrow community, since the military command allowed them to carry out community health projects in addition to work at the laboratory. As the Navy prepared to leave, the North Slope Borough became concerned about the loss of

veterinary services. Dr. Dalton was invited by the Borough to provide clinical care to local animals and to maintain the rabies control program (Philo et al., this volume). Veterinary services have been maintained as part of the NSB Health Department ever since.

When the NARL went into caretaker status, the North Slope Borough had already established a Conservation and Environmental Protection Office (CEPO). That program hired some of the Laboratory staff. By 1984 the work of the CEPO had expanded to the extent that pollution-monitoring matters were transferred to the Planning Department. A new NSB governmental unit, the Department of Wildlife Management, was formed, headed for a number of years by Ben Nageak (a former member of the NARL staff). Dr. Thomas Albert, who had been a visiting scientist at the NARL-ARF in the 1970s, returned from the University of Maryland to work full-time as Senior Scientist for the NSB Department of Wildlife Management. The staff of this department moved to the UIC/NARL facility (Building #360) and converted the former ARF (Building #350) to laboratories and living quarters for visiting technical personnel.

By the mid-90s, the North Slope Borough's Department of Energy Management had been established and located at the UIC-NARL complex. Borough oversight of the Barrow Gas Field was facilitated by convenient access to the contracted operators of the field and to the field itself.

POSTSECONDARY EDUCATION

The North Slope Borough also developed its own higher education system. Its North Slope Higher Education Center, founded in 1988, was renamed the Arctic Sivunmun Ilisagvik College in 1990. A college Science learning Center was established at UIC-NARL in 1990. In 1994 the college moved its administrative offices to NARL's Building #360, expanded its vocational training shops by renovating several Quonset huts at the NARL facility, and shortened its name to Ilisagvik College.

COMMERCIAL AND INDUSTRIAL ACTIVITIES

Since 1991 the retail franchise for Anchorage-based Spenard Builders' Supply has operated an outlet at UIC-NARL for construction materials. This Barrow franchise also handles sales and service of snowmachines, automobiles, all-terrain vehicles, boats and outboard engines from land and buildings leased from UIC at the NARL complex.

Private enterprise is represented also by several joint ventures with UIC or its subsidiaries: UIC Construction operates a vehicle maintenance shop at UIC-NARL; LCMF is an architectural and engineering firm with offices in Anchorage, in addition to its local office in Barrow at the UIC-NARL; Bowhead Transportation, the barge company which services North Slope communities from Seattle, has supervised Barrow operations from UIC-NARL.

COMMUNITY OVERSIGHT OF RESEARCH

Beginning in the mid-1970s, many of the people moving into newly created decision-making positions in the North Slope Borough government and the Ukpeagvik Inupiat Corporation had worked previously at the Naval Arctic Research Laboratory or in the field with NARL scientists. Their involvement with NARL helped to create a generally positive outlook toward both research and the uses of science in service of Native people (Albert, 1992).

The Borough and the Alaska Eskimo Whaling Commission (AEWC) increased their involvement with scientific research in response to growing petroleum exploration and development, as well as to international constraints put on subsistence harvest of the bowhead whale. The AEWC felt that it needed impartial oversight on proposed research and impartial reviews of government and industrial analyses of plans affecting its activities. Investigations with a bearing on community welfare have included wildlife and fisheries questions associated with petroleum related developments. Alaska's North Slope community (along with the rest of Alaska) benefits from wealth derived from the production of oil at Prudhoe Bay. At the same time, the Eskimo people know that the ocean is their garden and that high standards of stewardship must be maintained to protect it. To meet these needs, AEWC established a Science Advisory Committee (SAC) in 1980. John J. Kelly, former NARL director, was requested to chair it. Advisory service requested of the SAC rapidly broadened to such a degree that in November 1982 the Mayor of the NSB re-designated it the North Slope Borough Science Advisory Committee. SAC's services to the North Slope Borough continue to be called upon to the present time.

RESEARCH AND RESEARCH SUPPORT

Since the North Slope Borough's founding in 1972, its own funded investigations have been executed primarily through its Department of Wildlife Management. Departmental research has earned national and international recognition, which in turn has led to numerous collaborative research projects between the Borough's scientific staff and a variety of agencies, universities and private firms.

While the number of scientists at UIC-NARL and in residence at Barrow remained at a low point in the 1980s, scientists visiting Barrow with externally funded research projects were required to be determined and resourceful. If UIC or the NOAA-CMDL staff could not provide all necessary local assistance, researchers had little alternative but to seek help from staff of the Department of Wildlife Management for support, advice, and even accommodation on occasion. The Borough and the Department of Wildlife Management performed generously in NARL's lean years, particularly by extending support to graduate students.

Support for research projects in the Arctic remained a chronic problem, or, in the eyes of UIC managers) a chronic opportunity, until an upswing in arctic and

Barrow-based research projects began in 1990-91. Thereafter, research support began to develop around community initiatives, such as the setting aside of the Barrow Environmental Observatory (BEO) (Brown, this volume) and the recent non-profit incorporation of the Barrow Arctic Science Consortium (BASC). These developments are part of the transition of NARL that still goes on as the facility steers to a 75th anniversary celebration in 2022.

In summary, transition by the Navy's arctic laboratory did not end scientific inquiry, nor did it extinguish Barrow's inherent attractiveness to visiting scientists (e.g., Feder; Weeks, Weingartner and George; Zak et al., this volume). The non-resident scientific community experienced displacements and inconveniences, to be sure. On the other hand, local control has assured Barrow of more effective year round use of NARL real property to meet a greater variety of community needs. The fortunes of the NARL facility are less affected now by the vagaries of national missions and national funding. The multipurpose nature of the UIC-NARL can meet the needs of different types of users, including the scientific and engineering community as well as the people of Barrow.

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The Influence of Harry Brower, Sr., an Iñupiaq Eskimo Hunter, on the Bowhead Whale Research Program Conducted at the UIC-NARL Facility by the North Slope Borough

Thomas F. Albert, V.M.D., Ph. D.¹

ABSTRACT: This account documents the influence of an Eskimo hunter, the late Harry Brower, Sr., on the long-term bowhead whale research program conducted by the North Slope Borough (NSB). Mr. Brower's influence upon this research program began over 20 years ago and continues. This paper consists of five parts: 1) background information regarding Harry Brower, Sr.; 2) the bowhead whale "problem" of the mid-late 1970s; 3) scientists seeking help in the early 1980s; 4) identifying aspects of Eskimo Traditional Knowledge relating to the behavior of spring-migrating bowhead whales; and 5) the continuing long-term bowhead whale research program based in large part upon relevant aspects of Eskimo Traditional Knowledge. Over 80 references are cited in this documentation of the evolution of bowhead whale research by the NSB.

Key Words: Acoustical survey methods, Alaska Eskimo Whaling Commission (AEWC), International Whaling Commission (IWC), North Slope Borough (NSB), NSB Science Advisory Committee, Traditional Knowledge

BACKGROUND: HARRY BROWER, SR.

Harry was born in Barrow on 18 October 1924. He was one of the nine children of the legendary Charles D. Brower and his Eskimo wife, Asianguataq. Some of Charles Brower's arctic experiences were set forth in his book "Fifty Years Below Zero" (Brower 1942). With help from his father and mother, Harry grew into a well-respected hunter and whaling captain. He married Annie Hopson and together they had ten children (one dying in infancy). While still a young man (in the early 1940s) Harry began providing assistance to scientists working on the North Slope. During a significant part of his adult life he worked for the Naval Arctic Research Laboratory (NARL) in Barrow. During his 27 years at NARL Harry distinguished himself as an excellent carpenter (becoming head of the NARL Carpentry Shop) and as a guide and general source of North Slope information for many NARL scientists.

I met Harry during my first visit to NARL in 1975. Even at our first meeting Harry impressed me with his quiet competence and his detailed knowledge of northern Alaska wildlife. It was during my time at NARL's Animal Research Facility (July 1977-June 1979), while on sabbatical leave from the University of Maryland's Department of Veterinary Science, that I began to develop a relationship with Harry. From our earliest conversations it was obvious that he was a great

teacher, and throughout the 17 years of our friendship I always regarded myself as one of his students (Fig. 1). As recounted here, it was Harry's knowledge of the bowhead whale that came to our assistance time after time and even more importantly served as a guide for us over the years. The contributions of Harry Brower, Sr. to arctic science were recognized by the thanks he received from many scientists and by the award presented to him in 1988 by the Alaska Club of Sigma Xi. Sigma Xi is a scientific research society with membership of thousands of scientists in North America. Some aspects of Harry's life have already been documented (Brewster 1998; Hess 1988).



Fig. 1. Harry Brower, Sr., and the author during scientific consultations at Mr. Brower's house in the late 1970s. (Photo by Jerry Albert)

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Unfortunately, Harry Brower, Sr. died on 22 April 1992 having been predeceased by his wife Annie in 1984. They are survived by their nine children, eight of whom live in the dynamic community of Barrow (Fig. 2).



Fig. 2. Barrow, 10 August, 1989, with lagoon separating main portion of Barrow (foreground) from the Browerville portion. NARL and POW Main DEW site in distance toward Point Barrow. Chukchi Sea is on left, and the Beaufort Sea is barely visible beyond DEW site (note white "ball" of radome). (Photo by Tom Albert)

THE BOWHEAD WHALE "PROBLEM" OF THE MID-LATE 1970S

The bowhead whale is a large (to about 20m) ice-associated baleen whale that once existed in large numbers in northern circumpolar waters. Unrestricted commercial whaling, ending in about 1914, greatly reduced its numbers so that only five small populations are now recognized (Shelden and Rugh 1995). The largest, and best studied of these is referred to as the Bering-Chukchi-Beaufort Seas stock (BCB stock) or the Western Arctic stock or the Bering Sea stock. The BCB stock has long held cultural and nutritional significance for the coastal Native peoples of northern and northwestern Alaska, Chukotka (part of the Russian Far East), and northwestern Canada. Although commercial whaling on the BCB stock ended in 1914, coastal Native people in Alaska continued their centuries old subsistence harvest with its critical nutritional and cultural aspects. The subsistence harvest in Alaska is regulated by the U.S. National Marine Fisheries Service (NMFS) because that agency has regulatory control over whales in U.S. waters.

By the mid 1970s information regarding an increasing impact of the subsistence harvest in Alaska reached the International Whaling Commission (IWC) with a subsequent call for more data and for greater regulation (Durham 1979; Marquette and Bockstoce 1980; Mitchell and Reeves 1980a, 1980b). In response, field activities were initiated by NMFS off Point Barrow,

Alaska in an effort to count northward-moving spring migrants and thereby estimate the size of the BCB stock (Tillman 1980). NMFS also increased efforts to document the subsistence harvest (Marquette 1979; Tillman 1980). A large and very successful field effort was conducted by NMFS personnel during the spring 1978 bowhead migration (Braham, H., B. Krogman, S. Leatherwood, W. Marquette, D. Rugh, M. Tillman, J. Johnson and G. Carroll. 1979). Most of the NMFS work was centered at Point Barrow and included two camps of ice-based visual observers, some aerial survey in conjunction with the ice-based visual observers, and some recording of whale vocalizations.

From the initial census related fieldwork in 1976 and 1977 the IWC Scientific Committee believed that the data indicated a possible range of abundance of 600-2000 whales with a best estimate of 1300 (Tillman 1980). Data from the 1978 and 1979 NMFS field efforts resulted in a 1978 population size estimate of 1783-2865 (mean 2264) (Braham, Krogman, Johnson, Marquette, Rugh, Nerini, Sonntag, Bray, Brueggeman, Dahleim, Savage and Goebel 1980; IWC 1980b). The NMFS census effort depended primarily upon the visual sighting of passing whales by observers standing at the seaward edge of the shorefast ice (Krogman 1980). Some data were also supplied by a limited aerial survey that extended beyond the range of vision of the ice-based observers. The feeling that most spring-migrating bowhead whales passing Barrow were in the nearshore lead (Braham, Fraker and Krogman 1980) seemed reasonable to interested scientists in the late 1970s based upon the limited data available at the time. The "conventional scientific wisdom" among many at that time was that bowhead whales (like most people) were "afraid" of ice and therefore when migrating north in the spring tended to restrict themselves to the rather narrow open water channels (called "leads") in the ice and thereby avoid the "dangerous" ice. In view of increasing subsistence hunting impacts and such a low estimate of population size for the BCB stock, the IWC at its 1977 meeting set a subsistence harvest quota of zero for 1978 (IWC 1979a). Such precipitous action by the IWC caused great alarm among the bowhead whale-dependent Native people of the coastal areas of northern and northwestern Alaska (Adams 1979). Intense negotiations between the involved Native Alaskans and the U.S. government (NMFS) resulted in a U.S. request for a special IWC meeting later in that same year (December 1977). At that special IWC meeting a revised harvest quota was set for 1978 consisting of 12 landed or 18 struck, whichever came first (Tillman 1980; IWC 1979b). The harvest quota for 1978 was revised upward at the 1978

meeting of the IWC so that hunting would cease “when either 20 have been struck or 14 landed” (IWC 1979c). Concern at the IWC was such that the Scientific Committee at its 1978 meeting reconfirmed its recommendation:

“...that from a biological point of view the only safe course is to reduce the kill of bowhead whales from the Bering Sea stock to zero...”
(IWC 1979d).

In response to this marked increase in outsiders’ involvement with their bowhead subsistence harvest, the hunters formed the Alaska Eskimo Whaling Commission (AEWC). The AEWC was to represent the hunters in dealings with whale-related regulatory agencies at the U.S. federal level (NMFS and its parent agency the National Oceanic and Atmospheric Administration, NOAA), as well as at the international, or IWC, level (Freeman 1989). At the time of its founding (1977) the AEWC represented bowhead whale hunters in the villages of Gambell, Savoonga, Kivalina, Wales, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik. The AEWC comprised a single Commissioner from each village (therefore 9 Commissioners), one of whom was elected Chairman, and a small office, staffed by an Executive Director. The AEWC developed a management plan to formalize various procedures associated with the subsistence hunt. Over the years the AEWC has developed a cooperative agreement with NOAA, which, among other things, allows the AEWC to regulate the hunt at the local level. The AEWC has also become a strong advocate for minimizing industrial impacts to the whale’s habitat (Ahmaogak 1989; Brower and Stotts 1984). More recently (1994) AEWC membership was expanded to include the hunters (and a Commissioner) from Alaska’s Little Diomed Island.

One of the first actions of the AEWC following its founding was to point out what its members saw as inadequacies in the bowhead census effort conducted off Barrow by the U.S. government (Adams 1979). The AEWC and individual hunters believed that the census estimates of approximately 2000 bowheads were much too low based on their own experience as hunters, and on the general knowledge of the bowhead whale handed down from generation to generation (“Traditional Knowledge”).

By the end of the 1970s it was clear that the bowhead whale “problem” was really two problems. Problem One was the lack of data regarding estimation of bowhead population size and its trend. Problem Two

was the obvious difference in views separating the Eskimo hunters, who depend upon the bowhead whale, from the scientists drawn into the rapidly developing bowhead “issue” in U.S. northern waters.

SEEKING HELP IN THE EARLY 1980S

Although the NMFS had begun efforts in 1976 to count spring-migrating bowhead whales off Point Barrow (under the direction of Dr. Howard Braham), by the early 1980s the responsibility for this census work had been transferred to the people of northern Alaska. By the spring of 1982, the bowhead census effort and examination of harvested whales had become the responsibility of the North Slope Borough (Dronenburg, Carroll, Rugh and Marquette 1983). This placed a heavy burden upon NSB personnel who had to struggle with the design and conduct of field efforts, while balancing the value of the “conventional scientific wisdom” against the numerous forceful comments of Eskimo hunters regarding spring-migrating bowhead whales. The transfer of the census program to the North Slope Borough was in large part due to the efforts of Ray Dronenburg, who was also critical in organizing the Borough’s early field efforts.

Following the IWC’s imposition of harvest quotas, many Eskimo hunters during the late 1970s and early 1980s became suspicious of all scientists including those of us working for the North Slope Borough. Although the Eskimo hunters had developed many insights into the behavior of spring migrating bowhead whales, some were reluctant to share their knowledge with scientists for fear that their bowhead information would be used against them by the federal government, the IWC, or both. Partially offsetting this problem were positive personal relationships established during the late 1970s between a few scientists at the Naval Arctic Research Laboratory (NARL) and several key hunters in Barrow. In the 2-3 years before the Navy’s departure, NARL had become involved in a major bowhead research effort which was not, however directed at censusing (Kelley 1978; Kelley and Laursen 1980). NARL-based bowhead studies included examination of harvested whales at Barrow (Fig. 3). These scientists made the first systematic collection of a wide range of tissue specimens that were provided to several cooperating scientists for laboratory-based morphological, dietary, microbiological, serological, toxicological and genetic studies (Albert 1981a). These studies over three years (1978-1980) involved the detailed examination and sampling of spring and fall harvested whales, which required participating NARL scientific personnel to gain the support of the AEWC, the Barrow Whaling Captains Association (BWCA),



Fig. 3: Harry Brower, Sr. (facing camera) with his whale (80B8, male, 8.7 m) on the ice off Barrow 27th May 1980. We collected 156 specimens (for light and electron microscopy, serological, microbiological and toxicological evaluation, etc.) from this animal, making it the most extensively sampled bowhead whale (see specimen listing in Albert 1981a). Mr. Brower made a point of allowing us to sample his whale fully. Thanks to receiving his “blessing,” our subsequent access to whales taken by other hunters was excellent. (Photo by Tom Albert)

and key individual hunters in Barrow. Critical to gaining such approval of the study and the cooperation of successful hunters at the harvest site were personal relationships established between scientists and two highly regarded hunters (Harry Brower, Sr. and William Kaleak), the then Chairman of the AEWCA (Jacob Adams), and the then President of the BWCA (Eugene Brower). These personal relationships formed a nucleus of trust that facilitated later discussions (1981 and onward) regarding whale migratory behaviors that are relevant to the censusing of whales off Barrow.

When taking responsibility for the census effort, it was recognized that; a) we would have to conduct a very high quality research program since many would scrutinize our work (some critics might feel that counts would be inflated to justify a higher harvest quota), and b) we must give careful consideration to the many comments regarding whale behavior received from Eskimo hunters.

TRADITIONAL KNOWLEDGE OF THE BEHAVIOR OF SPRING MIGRATING BOWHEAD WHALES

Eskimo hunters believed that the IWC estimate of about 2200 bowhead whales passing Barrow in spring 1978 was far below the real number of whales. The hunters based their criticism on their knowledge that many whales were passing unobserved under the ice, and others were unseen because they swam far off-

shore, beyond the range of vision of the ice-based observers (Adams 1979).

Well-respected hunters (Harry Brower, Sr., Arnold Brower, Sr., Jacob Adams, Eugene Brower, William Kaleak, and others) all seemed to agree:

“There are a lot of bowheads out there that the scientists aren’t counting. Many are out in the ice and therefore are not seen when they pass by Barrow. As a result of poor counting the scientific community helps put these unfair quotas upon us.”

After listening to many hunters it became obvious to us that there was a major difference between the conventional scientific wisdom at the time, and Eskimo traditional knowledge regarding bowhead whale migration. Through discussions with senior hunters in Barrow, particularly Harry Brower, Sr., it became clear that traditional knowledge regarding the bowhead whale spring migration off Point Barrow could be restated as four testable concepts.

1. A bowhead whale population size estimate of about 2000 whales is a significant underestimate.
2. Bowheads pass Point Barrow on a broad front (up to 20 km wide) and are not restricted to the open water of the nearshore lead or any other lead.
3. Bowheads are not “afraid” of ice. They move through areas of broken ice and heavy ice, not just through areas of open water.
4. Bowheads can break ice to breathe. They use their blowhole area (Fig. 4) to fracture suitable ice from below to produce very small breathing holes that are easily missed by observers.

The North Slope Borough research program was designed to assess the validity of these concepts.

In most cases hunters also had direct personal experience concerning one or more of the above points. While many hunters provided information over a period of about five years, Harry Brower, Sr. was clearly the most critical in helping identify the four points noted above. Not only was Mr. Brower very patient in telling and retelling personal experiences but he kindly persuaded other senior hunters to share personal hunting experiences and to discuss information handed down through the generations. From having spoken to many hunters and from extended conversa-



Fig. 4. Partial view of bowhead whale (facing to the left) near visual census station at ice edge during “open lead” conditions. Note the prominent “peak” on the dorsal midline of the whale’s “bowed” head. The nostrils are located here. As Harry Brower, Sr., and other whalers showed scientists, whales use this peaked area, to apply pressure to the under-surface of the ice and thereby create cracks large enough to allow breathing. (Photo by John “Craig” George)

tions with Harry Brower, Sr. it became clear that there was a very specific body of knowledge regarding the bowhead whale that was held by these people. This knowledge had been handed down from fathers to sons for generations, it was tested over many years, it definitely had survival value, and in view of this the designation “Traditional Knowledge” seemed appropriate.

LONG-TERM BOWHEAD WHALE CENSUS EFFORT, SHAPED BY ESKIMO TRADITIONAL KNOWLEDGE

The AEWK and its hunters perceived that bowhead population estimates based only upon visual sightings made from the edge of the shorefast ice would be under-estimates of whale numbers because the many whales passing in the broken ice remained unseen and therefore underrepresented. If the bowhead population size remained consistently underestimated, the hunters knew that harvest quotas set by the IWC would be small and not sufficient to meet the cultural and nutritional needs of the people dependent upon the whale. Recognizing that the views of the AEWK and its hunters were largely ignored (as was the hunters’ traditional knowledge specifically related to bowheads) and recognizing that harvest quotas set by the IWC would be largely based upon available scientific evidence, the AEWK successfully negotiated with NMFS to take over the task of censusing spring migrating bowheads off Barrow. The AEWK oversaw a census effort in 1981 but then turned over responsibility for subsequent census efforts to the North Slope Borough

(NSB) under a cooperative agreement. This assignment of responsibility was reasonable since the NSB (approximately 88 000 square miles or 228 000 square kilometers area) is the regional government for northern Alaska and among its administrative units was a division (now known as the Department of Wildlife Management) whose staff had the technical expertise to conduct a scientifically sound bowhead census effort (Albert 1988).

In 1982 when the NSB took responsibility for censusing spring-migrating bowhead whales and for examining harvested whales, there was no shortage of advice provided (from other scientists and from Eskimo hunters) as to how best to conduct the fieldwork. In those days, the term “Traditional Knowledge” was new, and one could justifiably wonder how much “weight” should be given to it in the design of what was sure to be a long-term (many years) and very expensive (millions of dollars) research program.

When considering the design of the bowhead census studies, NSB personnel recognized that: 1) scientific data regarding the bowhead were very sparse; 2) the Eskimo people of AEWK affiliated villages have an ancient cultural and nutritional relationship with the bowhead; 3) the AEWK and its individual hunters have strong views (based upon traditional knowledge and personal experience) regarding the behavior of spring migrating bowheads; 4) the AEWK felt that bowhead population size estimates based primarily upon visual sightings by observers at the seaward edge of the shorefast ice off Barrow were unreliable, and were strongly biased downward; and 5) future census efforts to obtain estimates of population size and trend must withstand rigorous peer review and provide clear and convincing data to a wide audience (scientists, Eskimo hunters, conservation groups, industry personnel, etc.).

One of the earliest topics of discussion pertained to identifying the best site at which to conduct the bowhead census. After due consideration it seemed clear that the Barrow area was probably the best place to census the spring migrants because: 1) reports from all sources indicated that the whales consistently came close to shore (Figs. 5, 6) at Barrow; 2) available data indicated that soon after passing the Barrow area the whales “turned to the right” (moving in an easterly direction when entering the Beaufort Sea); and 3) the existing NMFS database was focused in the Barrow area.

Recognizing that bowhead data relating to estimation of population size and estimation of oil spill



Fig. 5. Aerial view of a well-defined open nearshore lead off NARL, May 1978. Visual census stations (informally called “perches”) have been located on suitably elevated piles of landfast ice in foreground, at water’s edge since the late 1970s. In later years 3-4 hydrophones have been hung over the ice edge, at about 200-m intervals. Drifting ice is visible at the far side of lead. (Photo by Tom Albert)



Fig. 6. Whaling Captain George Ahmaogak (at rear of boat) and fellow hunters in umiaq (wooden frame covered by skin from bearded seals) enter the well-defined open lead to pursue a passing bowhead whale in May 1980. Typical of whalers’ choice sites, the tent of this hunting camp is located at the edge of low, flat ice at right. (Photo by Tom Albert)

impacts are of great interest to a very wide audience, the NSB has sought review by: 1) the Scientific Committee of the IWC at its annual meetings; 2) the Science Advisory Committee of the NSB; and 3) sponsorship of five major conferences devoted to bowhead whale biology (Albert 1990; Albert, Kelley and Dronenburg 1982).

The NSB bowhead research effort and related activities that began in 1982 (Dronenburg, *et al.* 1983), continues to this day, and over the 18-year period has cost at least 10 million dollars. Most of the NSB bowhead research program has been devoted to esti-

imating population size and trend (for example, Murphy and Jarrell 1983; Raftery and Zeh 1998; Zeh, George and Suydam 1995) with additional basic biological studies regarding food habits, reproduction and estimating likely impacts (to eye, skin, respiration, etc.) should a whale contact spilled oil (Albert 1981b).

Initial bowhead census efforts conducted off Barrow by the NSB (Dronenburg, Carroll, Rugh and Marquette 1983; Dronenburg, George, Krogman, Sonntag and Zeh 1986) were similar to those conducted earlier by NMFS personnel (Braham, Fraker and Krogman 1980; Braham, Krogman, Johnson, Marquette, Rugh, Nerini, Sonntag, Bray, Brueggeman, Dahleim, Savage and Goebel 1980). Nevertheless, NSB biologists promptly began searching for ways to address criticisms raised by the AEW and its hunters. As the research program was designed and then implemented during the early to mid-1980s we relied very heavily upon the advice of Harry Brower, Sr. As noted earlier, these discussions identified the four basic aspects of bowhead behavior that guided the census effort from that point forward.

Mr. Brower was always willing to assist us and to spend many hours carefully explaining how he and the other hunters knew that the above points were correct. His own personal observations were especially helpful. He described how hunters with boats had seen and heard bowheads breathing in the broken ice on the far side of the lead. By contrast these whales could not be seen by ice-based census observers and are seldom seen by aerial observers. He also showed us how to find proof of their ice breaking behavior by looking for the small (~10-cm) holes in the ice where the whale came up from below and cracked the ice by exerting upward force with the blowhole area (Fig. 4). These small breathing holes, when seen by a person standing on the ice, appear similar to a glass window, with cracks radiating from a central point, after having been struck by a small stone or a “B-B” pellet (George, Clark, Carroll and Ellison 1989).

Mr. Brower and other hunters urged us to modify the census field program so that the unseen passing whales could be properly included in the count. He patiently and repeatedly explained that the unseen passing whales included: 1) unseen whales in the open water of a lead that were within the range of visual detection of ice-based observers; 2) whales in the open water of a lead that were beyond the range of visual detection; and 3) whales that were under the ice whether near to or distant from the observers. The hunters knew that whales passed Point Barrow on a wide front (sometimes 15 km or more wide) and that many were

traveling under the broken and drifting ice. The lead off Point Barrow can range from “wide open” (open water to the horizon) to “closed” when there is no open water, only shifting floating ice as seen from the visual counting station. Observers at the seaward edge of the shorefast ice will have a limited ability to see whales passing at a distance, and even during good viewing conditions the ice-based visual census cannot supply reliable data concerning whales passing more than 3 km (about 2 miles) offshore from the observers (Zeh, Raftery and Styer 1988).

It seemed initially that whales passing on a broad front should be detectable by aerial survey (Fig. 7), acoustic, or both methods. The use of limited aerial survey in support of the ice-based visual observers had been conducted by NMFS in the late 1970s and mid 1980s but few whales were usually seen beyond the nearshore lead (Braham, Krogman, Leatherwood, Marquette, Rugh, Tillman, Johnson and Carroll 1979; Krogman 1980; Nerini and Rugh 1986). Aerial survey results thus initially supported the view of many scientists that most bowheads use the nearshore lead when passing Point Barrow. Aerial surveys in 1985 and 1986, however, did show that a significant percentage of passing whales (61% and 84% respectively) could have passed beyond the effective visual range of the ice-based observers (Withrow and Goebel-Diaz 1989). Census-related aerial survey efforts at Point Barrow have two major drawbacks: 1) seeing whales in the broken ice is difficult as few were seen in early studies even though we now know that many were passing; and 2) the hunters object to aircraft flying overhead while they are trying to conduct a subsistence hunt. Although the use of aerial survey in support of censusing

off Point Barrow has not proved of great significance, spring aerial photogrammetric surveys have been very successful in helping determine length frequency of bowhead whales (Withrow and Angliss 1992). The use of “active sonar,” projecting a pulse under the water to detect whales (such as in detecting a submarine), would similarly be rejected by hunters as interference. During the spring of 1978 NMFS personnel had limited success in a small test of the usefulness of active sonar in detecting passing whales (Braham, Krogman, Leatherwood, Marquette, Rugh, Tillman, Johnson and Carroll 1979). The use of passive acoustics seemed the logical way to proceed when trying to locate passing whales that are not detected by visual observers. The passive acoustic technique involves use of underwater microphones (hydrophones) to document vocalizations, which can then be used to locate the vocalizing whales. Initial but limited use (primarily by NMFS personnel) of the passive acoustic technique during the 1979 and 1980 field seasons (Braham, Krogman, Johnson, Marquette, Rugh, Nerini, Sonntag, Bray, Brueggeman, Dahlheim, Savage and Goebel 1979; Clark 1983; Clark and Johnson 1984; Johnson, Braham, Krogman, Marquette, Sonntag and Rugh 1981) showed definite promise that the method could help detect unseen passing whales. After consulting with several acousticians it seemed that passive acoustics could be used to detect and then locate whales that vocalize. It also seemed that the use of passive acoustics, to supplement the visual census, would not interfere with the hunt. Mr. Brower’s observations regarding the passage of many unseen whales encouraged us to proceed with a feasibility study using passive acoustics. Dronenburg (this volume) describes the earliest phases of this feasibility study.



Fig. 7. Bowhead whale off Point Barrow as seen from an aircraft. Note the massive head (about 1/3 of body length) with its narrow rostrum and very large lower lips. The numerous white “spots” are areas of unpigmented epidermis representing small healed wounds probably due to ice contact. Images like this initially raised optimism for aerial survey census techniques. (Photo by personnel from National Marine Mammal Laboratory)

As part of the first conference on the biology of the bowhead whale (held early in 1982), the AEWSC Science Advisory Committee (later renamed the NSB Science Advisory Committee) recommended that the passive acoustic technique (including the localization of calling whales) become part of the spring 1982 field effort (Albert, Kelley and Dronenburg 1982). This marked an important point in the evolution of the census study design. Passive acoustical location of passing whales would become a major part of the field effort because: 1) limited acoustic efforts in 1979 and 1980 by NMFS were encouraging; 2) most Eskimo hunters had no objection to use of the technique while they were hunting; and 3) the AEWSC Science Advisory Committee recommended the technique. Consensus among several viewpoints was thus being achieved early in the NSB census program.

During the spring 1982 field season a significant and successful effort was made to determine the feasibility of actually locating vocalizing whales with an array of three hydrophones deployed at the edge of the shorefast ice. It was shown in 1982 that vocalizing whales could be located to distances of up to 10 km (6 miles) (Cummings and Holliday 1985; Cummings, Holliday, Ellison and Graham 1983). The actual locating of vocalizing whales in 1982 was a major step forward as compared to the earlier field studies in 1979 and 1980 when whales were detected acoustically but their position (location) could not be determined. Localizing calling whales at significant distances seaward from the visual observation site, enabled us to use acoustic data to develop correction factors for: a) whales too distant to be seen by the ice-based observers; and b) whales that pass when the visual census is adversely impacted due to unacceptable visibility (Figs. 8, 9) or dangerous ice (Krogman, Ko, Zeh, Grotefendt and Sonntag 1984).



Fig. 8. Scattered open areas in drifting ice off NARL, May 1978. Under such conditions, visual observers at edge of shorefast ice would likely see few passing whales. Aerial census techniques also proved to be unreliable under these conditions. Use of a hydrophone array at the ice edge allows passive acoustic location of vocalizing whales out to distances of 15-20 km (10-12 miles). (Photo by Tom Albert)

Another major advance occurred during the spring of 1984, when bowhead whales were acoustically tracked moving past Point Barrow (Clark, Ellison and Beeman 1985; Ellison, Clark and Beeman 1985). Therefore, it was during the spring of 1984 that the passive acoustic technique of locating whales was fully integrated into the census related fieldwork (Clark, Ellison and Beeman 1985; Dronenburg, George, Krogman, Sonntag and Zeh 1986). In order to utilize the acoustic data more fully a tracking algorithm was developed (Ellison, Sonntag and Clark 1987; Ko and Zeh 1988; Sonntag, Ellison, Clark, Corbit and Krogman 1986). That tracking algorithm was a computer pro-



Fig. 9: Continuous ice off NARL May 1978 (compare with Figs. 5 and 8). During "closed lead conditions" passing whales cannot be seen by ice-based or airborne visual observers. Whales nevertheless continue to pass, as documented with the aid of hydrophones that locate vocalizing whales. (Photo by Tom Albert)

gram that could link together a sequence of acoustic locations, visual sightings, or both, from the 1984 and 1985 field seasons, to form a whale track. Each track represented one whale that was detected more than once. This was an important event because the computer-assisted process of preparing "whale tracks" provided a high degree of assurance that the numerous whale call locations during a given time period could be "reduced" to a minimum or conservative estimate of the number of whales moving through the area. The tracking algorithm has become a major component in the evaluation of the combined visual and acoustic data, and has been further refined over the years (Clark 1989; Clark, Charif, Mitchell and Colby 1996; Clark and Ellison 1989; Sonntag, Ellison and Corbit 1988; Zeh, Raftery and Yang 1990). The importance of the acoustic technique was clearly shown during a four day period (3-7 May) in 1984 when the lead was "closed" by ice most of the time and only three whales were seen by the ice-based observers but yet the acoustic system showed that at least 130 whales passed by (Ko, Zeh, Clark, Ellison, Krogman, and Sonntag 1986). During this period most of the passing whales were beneath the ice of the closed lead and most were also well beyond the visual detection range of 3 km. A similar situation was noted in 1986 (Fig. 10) during a period when the lead was consistently narrow (usually 3 km wide or less) and sometimes clogged with ice (Zeh, Raftery and Styer 1988). During 574 hours of acoustic monitoring (with functional array) in 1986 a total of 50,552 bowhead calls were detected (Clark and Ellison 1989). In support of numerous comments by hunters regarding bowhead movement beneath the ice, there is some evidence that such whales may use the "reflection" of

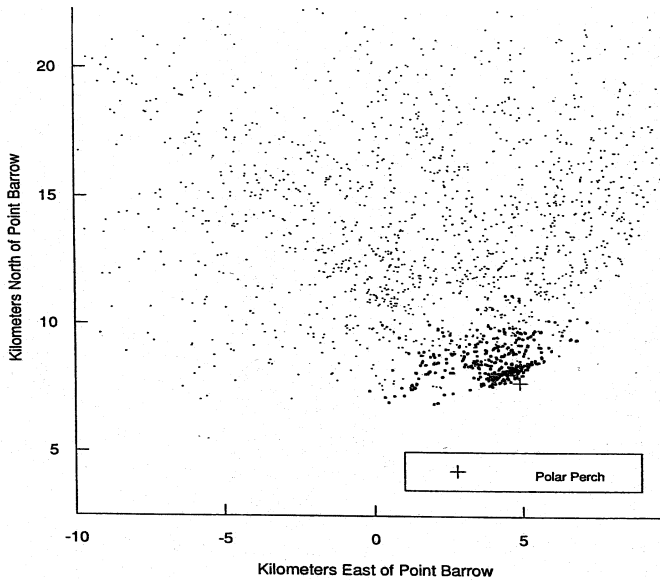


Fig. 10: Locations of bowhead whales seen by ice-based observers (large dots) and vocalizing whales detected through hydrophone array at ice edge (small dots) from 5 AM May 17 to 11 AM May 26, 1986 off Point Barrow. During that period there were 430 visual locations recorded during 218 hours of monitoring and 1534 acoustic locations during 45 hours of acoustic monitoring (107 acoustic locations were outside the plot boundaries). At this time the lead was consistently narrow (usually 3 km or less) and sometimes clogged with ice. As can be seen, the range at which passing whales can be detected acoustically is far beyond that of the ice-based visual observers. (Data from Zeh, Raftery and Styer 1988).

their own vocalizations to aid in navigation beneath the ice (Ellison, Clark and Bishop 1987; George, Clark, Carroll and Ellison 1989; George, Rugh and Zeh 1995).

The research program quickly evolved so that the census effort consisted of four basic components:

1. The visual detection, by ice-based observers, of passing whales in a lead out to distances of 3-5 km;
2. The recording of calls of passing whales (out to 15-20 km) by an array of hydrophones (3-4) deployed off the edge of the ice near the visual observers;
3. The passive acoustic location data are evaluated by cooperating acousticians;
4. The visual sightings data and the acoustic location data are combined by cooperating statisticians, and a population size estimate is prepared.

At the 1985 meeting of the IWC Scientific Committee, for the first time, acoustic location data were used to determine the minimum number of whales passing

the census site that were unaccounted for by the ice-based visual census (Clark and Ellison 1985; Clark, Ellison and Beeman 1986; Ko, Zeh, Clark, Ellison, Krogman and Sonntag 1986).

The idea of acoustically locating distant (up to 15-20 km) vocalizing whales, then using these locations to help estimate the number of passing whales, was only slowly accepted by the Scientific Committee of the IWC. It took about three years for the technique to be accepted. By 1985, after initial incorporation of at least some acoustics data, the IWC estimate of bowhead population size had risen to 4417 (95% confidence interval of 2613-6221) (IWC 1986). The first estimate of population size based upon combining visual and acoustic data took place at the 1987 meeting of the IWC Scientific Committee when they agreed the best estimate to be 7200 (2400 standard error) based upon data from the 1985 field effort (Gentleman and Zeh 1987; IWC 1988; Zeh, Turet, Gentleman and Raftery 1988). With the acoustic data more fully incorporated the IWC estimate rose to 7800 (95% confidence interval 5,700-10,600) in 1988 (IWC 1989). By 1996, with an improved statistical evaluation of the visual and acoustic data, the IWC accepted estimate of population size was 8200 with a 95% estimation interval from 7200 to 9400 (IWC 1997; Raftery and Zeh 1998). The estimated annual rate of increase (after hunting removals) from 1978 to 1993 was 3.2% with a 95% confidence interval 1.4% to 5.1% (Raftery and Zeh 1998). With increased precision of the estimates of population size and rate of increase, the size of the harvest quota has risen to more reasonable levels. The most recent harvest quota, set in 1997, allows a maximum of 280 bowhead whales to be taken during the five-year period of 1998 through 2002 (IWC 1998). The greater precision of the most recent estimates is largely due to: a) the highly successful field effort in 1993 when 3383 whales were actually detected visually (George, Suydam, Philo, Albert, Zeh and Carroll 1995); b) the full incorporation of acoustic location data; and c) application of a powerful statistical methods (such as Bayes empirical Bayes) to the evaluation of census-related data (Givens, Raftery and Zeh 1993; Raftery, Turet and Zeh 1988; Raftery and Zeh 1998; Raftery, Zeh, Yang and Styer 1990). The 1993 census field effort was the most successful yet, thanks to reasonable weather, a dedicated field crew, and the fine leadership of the effort by John "Craig" George.

There now seems to be no doubt that the bowhead whale population that passes Point Barrow is much larger than scientists had estimated a few years ago. There is also no doubt that the herd is increasing, that

the whales pass on a wide front (up to 15-20 km), are not “afraid” of ice, are not confined to the “open lead,” and can break ice to breathe.

Since 1985 when the Borough’s Department of Wildlife Management moved to the UIC-NARL Facility, our research effort has been conducted out of the UIC-NARL Facility. The Borough’s bowhead whale research effort has continued to the present and each year is the largest, or one of the largest, research projects staged from the “old NARL.” Approximately 75% of this research effort is concerned with estimating population size and trend while about 25% of the effort pertains to the study of specimens from harvested whales (morphology, microbiology, etc.) that help in estimating likely impacts should the whales encounter oil-fouled waters. The population related studies have been very fruitful over the years producing numerous publications, only a few of which are mentioned in this paper. Studies involving specimen materials have also been very productive, only a few mentioned here, resulting in a basic understanding of critical tissues and systems (Duffield, Haldiman and Henk 1992; Haldiman, Henk, Henry, Albert, Abdelbaki and Duffield 1984; Henk, Abdelbaki, Haldiman and Albert 1986; Henk and Mullan 1996; Henry, Haldiman, Albert, Henk, Abdelbaki and Duffield 1983; Philo, Hanns and George 1990; Smith, Skilling, Benirschke, Albert and Barlough 1987; Tarpley, Hillmann, Henk and George 1997; Tarpley, Sis, Albert, Dalton and George 1987; Zhu 1998).

In acknowledging tissue-based studies, it is important again to refer to the critical role of Harry Brower, Sr. During the “early days” (late 1970s and early 1980s) of our efforts to examine and sample harvested whales, Mr. Brower’s assistance was critical, such as during the spring hunt of 1980 at Barrow, in gaining hunter acceptance of our efforts (Fig. 3). Once we had the “blessing” of Harry Brower, Sr., hunter resistance to our efforts at the harvest site virtually disappeared.

Over the years since 1981, the Borough (with help primarily from the State of Alaska and the Federal Government) has spent millions of dollars in gaining a better understanding of the spring migration of bowhead whales passing Point Barrow. Although many people have contributed to this successful research effort the single most important person, in my opinion, is Harry Brower, Sr. He “pointed the way” when the path for scientists was not clear. It is a pleasure to report that his basic observations (and those of his fellow hunters) have been fully validated through many years of scientific effort. The success of this program is strong

evidence that scientists and other technical people should carefully consider the traditional knowledge held by local people.

In a field and analytic effort as large as described above and extending over so many years there have obviously been many contributors. It is a pleasure to acknowledge the critical help provided, especially in the early years, by members of the Barrow Whaling Captains Association (in particular long-time President Eugene Brower, William Kaleak, Arnold Brower, Sr.) and by the Alaska Eskimo Whaling Commission (in particular Burton Rexford, Maggie Ahmaogak, Marie Adams Carroll, Jessica Lefevre, Lynn Sutcliffe). Early help was also provided in Kaktovik by Herman Aishanna, Joe Kaleak and Nolan Solomon, and in Point Hope by John Oktollik, Sr.

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As mentioned in this chapter, Harry Brower, Sr. was the “guiding light” in the early days as the study design was structured and modified. By helping with this study Harry has influenced the bowhead-dependant people from Saint Lawrence Island to Barter Island. As is true for most great people, the good done by Harry Brower, Sr. extends far beyond his home, and far beyond his lifetime.

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NARL's Scientific Legacy, Bridging to the 1990s

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ABSTRACT: The Naval Arctic Research Laboratory was the support base for much of the early research conducted in the U.S. Arctic. After the Navy left, the North Slope Borough, Department of Wildlife Management leased the Arctic Research Facility (ARF) building to support their own and other research projects. Cooperative research with the U.S. Fish and Wildlife Service conducted from ARF in the 1990s included Steller's eider nesting biology, king and common eider migration counts, and king eider contaminant studies.

Key words: Arctic Research Facility (ARF), NARL history, North Slope Borough, bowhead whales, eider ducks

I first arrived at NARL in 1985 after it had been vacated by the U.S. Navy, but before its official transfer to the Ukpėagvik Iñupiat Corporation (UIC) although it was already unofficially referred to as UIC-NARL (Kelley and Brower, this volume). The North Slope Borough's Department of Wildlife Management leased the Arctic Research Facility (ARF—formerly the Animal Research Facility, Building #350) from UIC for the Bowhead Whale Census project. I was hired as a bioacoustics technician on the whale project and although most of my time was spent on the sea ice (Fig. 1) deploying and maintaining arrays of hydrophones to record bowhead whale vocalizations (Fig. 2), the ARF (Fig. 3) was the logistics base.

The ARF was a candy store for this young arctic biologist. Throughout the building and grounds was evidence of the studies that had been conducted there. The chambers where Laurence Irving and Pete Scholander measured basal metabolic rates for investigating physiological adaptations to cold (Elsner, this volume) were visible from the radio room window. On the wall of the main hallway hung the genealogy of a captive wolf pack that had been the object of study for some years. Nearby shelves held preserved specimens of curious bits of tissue labeled with names that matched those on the chart. The wolf pen, cages, and observation towers were now used for storage and housing. The polar bear cages were eerily quiet and frightening even though empty, but there were plenty of stories told about "Irish" who was at least one of the occupants.

Around 1986, the original NARL Dining Hall (Building #50—Norton, this volume) was torn down. Thereafter, the dining room at ARF at least seasonally



Fig. 1. Whale census "perch" showing observers and windbreak at the edge of nearshore open lead, 1986. (See Albert [this volume] for a discussion of census perches.)

replaced Building #50 as the social hub, where scientists and nonscientists from all over the world could share meals and ideas across disciplines and cultures. I had the opportunity to exchange ideas with many outstanding people in that room: Robert Rausch, Jack Lentfer, Robert Elsner, John Bockstoe, Chris Clark, Bill Ellison, Erich Follmann, George Divoky, Bernd Wursig, Bernd Heinrich, John Wingfield, Henry Huntington, Bruce Krogman, Judy Zeh, Lynne Dickson (Canada), Zhang Qingsong (China), Will Steiger (ad-

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Fig. 2. Acoustics camp and shed-sled with hydroacoustics instruments, 1988.



Fig. 3. Arctic Research Facility (ARF), Camp Building #350, as it appeared in 1987.

venturer), Flip Niklin (photographer) to name a very few. I also had many great discussions with the many not-yet-famous dedicated technicians and field assistants working on the many projects that the North Slope Borough encouraged, supported, or funded over the years. While Ben Nageak was the Director of the Department of Wildlife Management, he would visit the ARF early in the morning (Fig. 4). He would sit down at the table with sleepy scientists and completely fill the room with his overwhelmingly positive attitude, accompanied by his loud irrepressible (and off-color) humor. Before any of us could even partially retaliate, he would be off to his office (Building # 360). I would find myself chuckling several times each day as I recalled highlights of Ben's visit that particular morning. I have enjoyed knowing that Ben's introduction to science was catching lemmings (worth one dollar each) for Frank Pitelka at NARL. I returned each spring to work on the Whale Census through 1988. This project allowed me to observe and participate in spring subsistence whaling activities. My first trip to a successful



Fig. 4. Benjamin P. Nageak and his son, Robert, in the ARF dining facility, helping fold laundry. (This picture was taken in 1997, when Mr. Nageak was serving as Mayor of the North Slope Borough).

whaling camp was by riding double on a snowmachine with Charlie Brower. Most of the snow had melted, leaving only rough, wet, and slippery sea ice. Wet tipped the machine over no less than four times on the way out to that whale. The celebration, however, more than made up for the bruises. Although whaling is not part of my culture, I was welcome to help pull the whales onto the ice, and to share *unaluk* (fresh boiled *maktak*) with the others helping in the harvest. At the direction of the whaling captain, the whale was cut and distributed quickly and expertly by the crew. It was clear that I was witness to an old and culturally important event.

Having worked at UIC-NARL in the late 1980s I recognized the opportunities and the support for research at Barrow. So when I began working for the U.S. Fish and Wildlife Service in 1990 and found that they were concerned about the status of eider ducks, it made sense to join the North Slope Borough, Department of Wildlife Management in the development of several projects. Spectacled eiders (*Somateria fischeri*) and Steller's eiders (*Polysticta stelleri*) were being reviewed for potential listing under the Endangered Species Act due to population declines. King (*S. spectabilis*) and common (*S. mollissima*) eiders are an important supply of spring meat for the people of the North Slope and the Borough was concerned that at least two of four eider species appeared to be declining.

With Robert Suydam, a recently hired biologist with the North Slope Borough, Department of Wildlife Management, I began a project in the summer of 1991, to study the reproductive biology of the least known eider, the Steller's eider (Fig. 5). At that time, Steller's eiders were thought to be extinct as a breeding bird on



Fig. 5. Robert Suydam of the NSB Department of Wildlife Management, holding a male Steller's Eider.

the Yukon-Kuskokwim delta, which was one of only two known breeding areas in Alaska. The other area was the vicinity of Barrow (Kertell, 1991). We found six nests near Barrow that year; the first nests recorded for that species in Alaska in 16 years.

Over the next six years of study we found that this rare and beautiful sea duck did not nest every year. No nests were found in 1992 or 1994, whereas nesting did occur in 1993, 1995, and 1996 (Quakenbush et al., 1995; Quakenbush and Suydam, 1999). Interestingly, all nesting years corresponded with years of high lemming numbers. When we reviewed the shorebird studies conducted near Barrow in the 1970's (Myers and Pitelka, 1975a, 1975b; Myers et al., 1977a, 1977b; 1978a, 1978b; 1979a, 1979b; 1980a, 1980b; 1981a, 1981b) we found that this relationship with lemming numbers could also be documented in those years (Quakenbush and Suydam, 1999). Steller's eiders nest on the ground (Fig. 6) and, although they are well camouflaged they have little defense against arctic foxes (*Alopex lagopus*). Near Barrow, Steller's eiders appear to nest near pomarine jaegers (*Stercorarius pomarinus*) and possibly snowy owls (*Nyctea scandiaca*) to take advantage of the vigorous nest



Fig. 6. Female Steller's Eider on nest. Photo by Kim Fluetsch.

defense provided by these birds. Perhaps without this protection, it is not energetically or evolutionarily worth laying eggs to feed foxes.

In 1994 and 1996, we counted king and common eiders passing by Point Barrow from the ice edge during the spring migration (Fig. 7) and from the base of the Point Barrow spit during the fall. We compared our numbers with those of similar counts conducted in 1953 (Thompson and Person 1963), 1970 (Johnson 1971), 1976 (Woodby and Divoky 1982), and 1987 (Suydam et al. 1997). We found that the king eider population appeared to remain stable between 1953 and 1976 but declined by 56 percent from approximately 800 000 birds in 1976 to about 350 000 in 1996. Estimates of Common Eiders passing Barrow similarly declined by 53 percent from 155 000 birds in 1976 to 70 000 in 1996 (Suydam et al, 2000).

We initiated a study to determine the levels of contaminants in eider tissues to address health issues from the perspective of the bird population and that of the people who eat the birds. Human health issues lie outside the mandate of the U.S. Fish and Wildlife Service, which focuses solely on the bird population perspective. Joining with the Borough and its mandate to consider human health perspectives made it possible for a single sample collection and analysis to serve mandates and purposes of both organizations.

These cooperative efforts allowed research to be conducted on a much larger scale and on a greater diversity of topics than the budget of either the U.S. Fish and Wildlife Service or the Borough would have allowed independently. By leasing the ARF, the Borough has kept the spirit of NARL and its contribution to arctic science going beyond the well-funded Navy days by providing a place for scientists.



Fig. 7. Taqulik Hepa (left) and Tim Obritschkewitsch, counting passing eiders from a “perch” similar to those long used in visual census of bowhead whales, spring, 1996.

Barrow is a science Mecca. Its latitude (71° N), and its position at the confluence of the Chukchi and Beaufort seas makes Barrow ideal for marine (Weingartner and George, this volume) and terrestrial studies of all disciplines. Of equal importance to Barrow’s location, however, are the people who live there and recognize its scientific importance. Some of the residents of my acquaintance who have made Barrow the arctic science hub that it has become are Ben Nageak, Dr. Tom Albert, Charlie Brower, Craig George, Marie Adams Carroll, Geoff Carroll, Dave Norton, Robert Suydam, Warren Matumeak, George Ahmaogak, Richard Glenn, Glenn Sheehan, and Raynita “Taqulik” Hepa.

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Aerogeophysical Research in the Arctic

Lawrence A. Lawver¹, John Brozena², and L.C. Kovacs²

ABSTRACT: With new technology, U.S. Navy research has made a modest return to the Laboratory in Barrow, from which it has staged gravimetric and magnetometric flights over parts of the Arctic Basin in recent years.

Key words: Canada Basin, Northwind Ridge, Chukchi Cap, Naval Research Laboratory (Washington DC)

Until recently, airborne geophysical research in the Arctic was limited to magnetic surveys (see Coles and Taylor, 1990 for a review). The Soviets started reconnaissance magnetic surveys in 1946 and continued until the late 1960s (Demenitskaya and Hunkins, 1970). U.S. reconnaissance surveys began in 1950-52 with a U.S. Air Force and U.S. Coast and Geodetic Survey project covering the central Arctic (King and others, 1966). Project magnet aircraft flew several flights over the Arctic between 1960 and 1963 under the auspices of the U.S. Naval Oceanographic Office. The University of Wisconsin Polar Research Institute conducted extensive surveys in 1961, 1963 and 1964 (Ostenso and Wold, 1971; 1973). Canadian researchers covered much of the Arctic adjacent to the Canadian Arctic Islands during the 1960s and in 1970.

Beginning in the early 1970s, U.S. Navy aircraft produced significant technological advances and allowed far more detailed systematic surveys to be done over much of the Arctic Ocean (Coles and Taylor, 1990). The details of much of the early Naval Research Laboratory work has been published in two landmark papers, Vogt and others (1979) and Taylor and others (1981). In the 1990s, the Naval Research Lab returned to systematic mapping of the geophysics of the Arctic but this time included gravity and radar altimetry as well as magnetics. During the previous five field seasons much of the western Arctic accessible from North America has been mapped on a 6- or 8-nautical mile line spacing. The first season in 1993 was flown out of Thule, Greenland, the second out of Deadhorse, Alaska and the last three seasons have seen the Naval Research Lab presence back at NARL.

Magnetics and gravity measurements are made by the Naval Research Lab using an Orion P-3 outfitted with two ZLS precision gravimeters and a total field intensity magnetometer. Positioning of the plane is done with four global positioning system (GPS) units with a second set of four receivers located at NARL. Precise positioning of the plane allows exact flight lines to be flown and significantly enhances the quality of the gridded data. Combination of the recent data with the older data generally results in degradation of the newer data.

For each season, 120 hours of flight time are allowed between the NRL base at Patuxent River, Maryland and the finish of the survey at Barrow. Excluding the transit to Barrow, about 13 flights of an average 8 hours each were accomplished. Survey speed was 170 knots flown at a standard elevation of 1200 feet. Transits to and from the survey areas were done at about 320 knots at elevations of up to 21 000 feet to conserve time and fuel. Both the 1996 and 1997 surveys began and ended essentially at Barrow, so data collection was maximized. Approximately 16 000 n. m. of data were collected on each survey. The 1997 survey covered the area of Northwind Ridge and Chukchi Cap from 72°N to 80°N and from 176°E to 150°W. The survey box covered about 750 km by 750 km or roughly 550 000 km².

The 1995 and 1996 seasons covered much of the deep part of the Canada Basin. Results indicate that the Canada Basin did not open as a single-stage opening about a pivot point located near the Mackenzie Delta. It appears that there may have been three or possibly four distinct stages to the opening. Perhaps as the Arctic Alaska/Chukotka block swung away from Arctic Canada, it ran into various obstacles as it contacted the Siberian plate. Continued opening resulted in a different pattern of magnetics and gravity.

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The enigma to the simple opening hypothesis has always been the position and composition of the Chukchi borderland including Northwind Ridge. Results of the 1997 gravity survey covered the Chukchi borderland region and indicated a prominent gravity low running along the base of Northwind Ridge and a gravity high outlining the Chukchi Cap. The gravity low may indicate transform motion between the continental pieces of Northwind Ridge and the deeper Canada Basin.

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The ARM North Slope of Alaska and Adjacent Arctic Ocean (NSA/AAO) Cloud and Radiation Testbed (CART) Climate Change Research Facility: Carrying on the Tradition

Bernard D. Zak¹, Knut H. Stamnes², and Kevin B. Widener³

ABSTRACT: Barrow is likely to retain its traditional role of being a key site in worldwide assessment of environmental variation, particularly through research into the effects of clouds on global climate change. The paper describes development and operation of the Cloud and Radiation Testbed (CART) adjacent to UIC-NARL, how this facility is integrated with other regional efforts, and its connections to research on a global scale.

Key Words: General Circulation Models (GCM), clouds, radiant energy, global climate change, U.S. Department of Energy (DOE), Atmospheric Radiation Measurement (ARM)

While most of the chapters in this volume look back over the past 50 years, this one looks *forward* to the coming decades, perhaps to the next 50 years or more. On 1 July 1997, Martha Krebs, Director of the US Department of Energy (DOE) Office of Energy Research, Ben Nageak, Mayor of the North Slope Borough, and Max Ahgeak, President of Ukpogvik Inupiat Corporation (UIC—the engineering, construction, and support contractor) formally dedicated the North Slope of Alaska and Adjacent Arctic Ocean Cloud and Radiation Testbed site. They jointly cut ribbons to release a weather balloon in a ceremony that symbolized partnerships in developing these new climate change research facilities near Barrow.

The Barrow site is part of DOE's Atmospheric Radiation Measurement (ARM) program, the goal of which is to improve the treatment of radiant energy flows for General Circulation Models (GCMs), especially as modulated by clouds. Such improvements would be expected to enhance the skill of both climate change and numerical weather prediction models. The North Slope site is the last of three long-term CART sites to be established by DOE for this purpose. The other two are in the Southern Great Plains of the US (north of Oklahoma City), and in the Tropical Western Pacific (northeast of Australia). Each site (Fig. 1) has a projected operating lifetime with ARM funding of 7-

10 years. The data streams from these sites are used by academic and government researchers worldwide, many with projects also funded by ARM.



Fig. 1. The NSA/AAO ARM site in geographic relation to the other two ARM sites, in the southwestern U. S. and in the southern Pacific. Image, based on ARM Website (1999).

The instrumentation for the first element of the North Slope CART site is being installed on National Oceanic and Atmospheric Administration (NOAA) Climate Monitoring and Diagnostics Laboratory (CMDL) land near Barrow, but with a laboratory and offices in the UIC-NARL complex (Fig. 2; see also, Townshend, this volume: Fig. 1). Over the early years of the project, CART instrumentation will grow to be quite extensive. We have in place a multi-level, 40-m meteorological tower, an instrumentation shelter, a raised deck for upward-looking radiometric instrumentation, and two additional decks of comparable size (6 by 6 m [20 by 20 feet], installed

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accommodates ARM instrumentation on their land under the NOAA cooperative program, provides ARM with the data from their extensive trace gas and aerosol monitoring instrumentation, consults on experiment design and execution, and will make use of the ARM data and T1 line. ARM also works closely with the National Weather Service itself: the Barrow Observing Office, the Fairbanks Forecast Office, and NWS Alaska Regional Headquarters in Anchorage.

If all goes according to plan, over the next few years, the ARM instrumentation at Barrow will be augmented by similar ARM instrumentation in the vicinity of the inland village of Atkasuk, and in the vicinity of Oliktok Point (Fig. 3). Several automated weather stations are expected to fill in the area between these facilities. The goal of this extended instrumentation array is to permit studies to take place on the formation, evolution, and eventual evaporation of clouds under arctic conditions. Such studies require instrumentation over an extended area.

Within months of the dedication ceremonies, ARM also participated in the SHEBA (Surface Heat Budget of the Arctic Ocean) experiment. SHEBA is funded primarily by the National Science Foundation and the Office of Naval Research, but with includes participation by several other agencies, both national and international. For SHEBA, a Canadian icebreaker carried

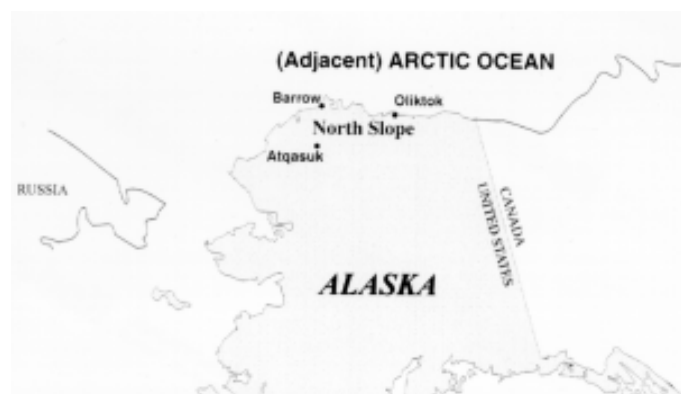


Fig. 3. CART site location, and geographic relation of outlying sites for future development. Image, courtesy of ARM.

SHEBA instrumentation into the arctic ice pack in 1997 where it operated for one full year (Fig. 4). The objective is to understand the heat balance of the ice pack so that its future behavior in the presence of global climate change could be more accurately predicted. The ARM instrumentation for use in SHEBA is a subset of the ARM instrumentation to be operated at Barrow. During SHEBA, the National Aeronautics and Space Administration (NASA) also conducted a related instrumented aircraft-based study called FIRE



Fig. 4. Aerial view of the Canadian icebreaker, des Groseilliers, on station in Arctic Ocean pack ice, surrounded by instrument huts and installations for the SHEBA project, north of Barrow. Image, courtesy of ARM.

over the region (FIRE: First ISCCP Regional Experiment; ISCCP: International Satellite Cloud Climatology Project). The ARM/SHEBA instrumentation will be used in the expansion of the NSA/AAO site.

Planning for the NSA/AAO ARM site has been in progress since 1991 (Editor's Introduction, this volume: Fig. 1). If we have planned and built well, our successors will be presenting papers at a meeting in Barrow 50 years from now, to celebrate the first 100 years of NARL.

ARM is funded by the Environmental Science Division, Office of Energy Research, US Department of Energy. The DOE ARM Program Manager responsible for the NSA/AAO CART site is Wanda Ferrell.

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V. Perspectives on UIC-NARL's Future

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Future for the NARL Camp Dining Hall?

David W. Norton¹

ABSTRACT: Cafeteria-style dining played a bigger role in NARL history than is generally recognized. Traditions honored at the Mess Hall sustained communication and interactions among diverse people throughout the Camp and the community. The reasons for, and consequences of, abandoning these traditions are examined, by comparing the current NARL facility with others, such as one in Nuiqsut.

Key words: Dining Hall, Mess Hall, Alaska roadhouse tradition, Nuiqsut, Kuukpik Corporation, UIC-NARL, hospitality.

Arguments over the anatomical seat of the human soul are supposedly waged by philosophers. Reed and Ronhovde (1971:651) characterize NARL's institutional soul as a "university in a Quonset hut." Their metaphor could call to mind one of several parts of the NARL complex or "Camp" housed in Quonset buildings. My mind, for one, forms images of the Camp Dining Hall, as I experienced it over many years, beginning in 1968. Compared to other parts of the Camp's anatomy, the contractor-operated dining hall served as the one rallying point where investigators, townspeople, visitors, and staff could communicate daily. Meals and coffee breaks at the Mess Hall provided everyone respite from the clutter of scientific or logistic detail. Its relaxed setting encouraged participants to listen and contribute to discourse that some people recall as more stimulating and memorable than most formal university seminars.

Central to the dynamics of NARL's Dining Hall was its colorful cast of characters. Venturing there was apt to be rewarded by conversations among scientists debating interpretations of field data. Or the reward might be riotous laughter over embellished stories of misadventures in the pursuit of arctic phenomena. Dr. Steve MacLean (1992:37) identified a singular brand of NARL humor, which he called "merciless." Serious and comic dining hall encounters cemented bonds and friendships throughout the camp (Fig. 1). Recalling the conviviality of the Camp Dining Hall makes it hard to believe that anyone in those days could have preferred to withdraw from the company of colorful characters to eat alone. Abundant and delicious food was always welcome punctuation for periods of hard work (see box: "Tiny") but adventures in fellowship and entertainment made even Sundays' prime rib dinners slightly larger-than-usual excuses for "being there." NARL's dining facility extended hospitalities in the style of the



Fig. 1. Holiday merriment in the Camp Dining Hall (Building # 50) in the mid-1960s. Standing at table, L-R: Erna Schindler, Chester Lampe, and Elizabeth Lampe. Norman Lampe in the background. Photo courtesy of John Schindler.

many roadhouses that have offered refuge for a century or more along Alaska's routes of travel (see box: Custom and Courtesy).

NARL's Camp Dining Hall proved as resilient as an Alaska roadhouse, too. Like many a roadhouse resurrected after flood or fire, it survived relocation from Quonset hut #50 (Fig. 2) to the main NARL building (# 360, in space that had served as the NARL Library, 1969-1980). Departure by the U.S. Navy and University of Alaska had failed to kill it. The Dining Hall remained the Camp's focal point for social and intellectual exchanges—gossip center, if you prefer—in the first 14 years of UIC management after 1980. Encour-

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REMEMBERING “TINY” AND HIS COOKING

Who could eat at the NARL Camp Dining Hall without seeing or at least hearing of Tiny, arguably NARL’s most famous cook? Those of us fortunate enough to dine regularly at the Mess Hall were continually amazed by the great food served up by the kitchen staff. After a cold day in the field (or even hard days in warmer labs or offices) pleasure began reaching out to us during the walk down the aisle between dining tables, as good smells wafted their way from piles of food awaiting each guest. Next, the sight of Tiny holding forth while he dispensed portions was nearly always worthy of comment, whether it was a visitor’s first or a regular’s 100th time through the food line. In his official duties, he was a friendly and decidedly pudgy figure, always ready to exchange a few words of conversation. Tiny’s prominent belly hung over his belt, and sometimes rested grandly on the edge of a table or other work surface in the chef’s habitat. Tiny’s imposing posture inspired giggles and admiring comments; others chose to scold the cook (in a nice way) for the quantity and richness of his servings. Although his food was famous for its grease, we all found it delicious and could not resist filling up on it. Tiny was one of the more famous of NARL’s team of chefs whose combined efforts prompted some speculation on how many years of operation it would take the Trans-Alaska Pipeline to deliver enough calories to match the total delivered by the NARL Mess Hall.

—Tom Albert

aged and regularly joined by the UIC kitchen staff (Fig. 3), patrons lingered over meals, conversations, and the ever-available coffeepot.

Not until 1994, when the local college leased all but the Science (Laboratory) Wing of Building # 360, did the Camp Dining Hall start to lose its roadhouse resiliency. New managers withdrew it from a focal role in the camp community. Long-time users and friends of NARL wished UIC-NARL’s new tenant well. Wouldn’t a “university in a Quonset hut” naturally become a college in a Quonset hut? Dedication of much of Building # 360 to postsecondary education did not usher in that transition. The college abandoned key Camp Dining Hall traditions, and transformed the environment within the facility into something noticeably different from its pre-1994 condition. The atmosphere that had appealed to youngsters (see text box: Lane Franich) disappeared.

At first, those of us continuing to work from the UIC-NARL Science Wing did not see manifestations of new management as symptoms of life-threatening illness in

CUSTOM & COURTESY

It was customary for airplanes returning to Camp during hours of meal service at the Mess Hall to “buzz” Building # 50. NARL pilots used this courtesy signal to alert kitchen staff to keep food hot, or put out extra servings. Whenever pilots rattled the dishes this way, an expeditor might scramble from his own meal, and return 20 minutes later leading an incoming crew to be fed.

—Dave Norton



Fig. 2. NARL Camp Dining Hall, Building # 50 exterior view, in 1975. Photo, courtesy of Brian Shoemaker.



Fig. 3. Dining Hall sociability in the Camp Dining Hall, early 1994. Coffee pots circulated among lingering diners, and pictures still adorned the walls. Seated, L-R: Tom and Phyllis Clarke, Earl and Chris Finkler; Standing: George Karn.

the mess hall. By stages, its hours of service were cut, and prices raised. Coffee pots were padlocked between meals, as if to declare the facility off-limits. The cafeteria soon suspended even this reduced service for two-week stretches between academic semesters. In accompanying stages, sterility crept into the décor. Pictorial reminders of the past, and of surrounding cultural and arctic environments of northern Alaska—everything that distinguished this space from the lobby of a motel anywhere in America—were stripped from its walls (Fig. 4). Diverse visitors and workers within the NARL complex lost claim to their traditional “hangout” for unhurried social exchanges.



Fig. 4. Post-1994: a rare get-together in the NARL Dining Facility between meals. Kenneth Toovak, Sr. (left), Richard Glenn, Glenn Sheehan, and (most clockwise) Betty Kinneauvauk-Smith discuss honors being conferred upon Kenneth Toovak, Sr. by the American Polar Society, summer, 1998.

Today, the shell of the UIC-NARL Dining Hall clings to life, feeding a dwindling segment of the public, to which it dispenses food in several punctual doses daily. Townspeople may feel welcome to exchange money for food, but pointedly unwelcome to linger. Carryout containers are available, so patrons are encouraged to retreat to offices, or to escape in their vehicles to eat elsewhere. No spark of camp cohesion remains. The facility attracts few steady diners to lament its former vitality, or to notice how the once-merry space echoes footsteps hurrying through it toward livelier destinations.

These recent developments invite analysis and interpretation for their wider implications. Several explanations could account for how the dining hall arrived at

its present state. Explanations fall into active (deliberate) and passive (unplanned) categories.

On one hand, Barrow’s vocational college could be consciously shielding its operations and buffering its students from the distracting activities of the wider community. Discouraging outsiders’ presence in the facility may be aimed at shoring up an internal personality. This could be a strategy, within which cutting ties with NARL’s past are incidental tactics. Despite being contractually pledged to maintain a public cafeteria, Building # 360’s primary tenant may want to curb its food service to being no more publicly inclusive than what is normally expected of any cafeteria in a public K-12 school. Former patrons might regret being excluded, but could hardly begrudge success by this configuration, especially if the new exclusivity brings about healthy internal conviviality among college students, faculty and staff. After all, self-absorption by educational institutions, and their tendency to become cloistered little worlds unto themselves are patterns amply illustrated elsewhere. Efficiency-minded cafeteria managers cannot be blamed for regarding “university in a Quonset hut” as an empty metaphor. NARL’s legacies to arctic science are inconvenient relics of history attached to the facilities rented and operated by a goal-oriented school.

On the other hand, perhaps the dining facility’s downscaling was not thoughtfully designed, but came about inadvertently. That is, such policies as padlocking drink dispensers were neither considered for consistency with a primary mission of the facility, nor reviewed for possible consequences. In that case, the loss of public clientele and revenue arose from a series of *ad hoc* decisions, each made in isolation, and each decision pinned to budgetary constraints. (One wonders at the size of financial subsidy now required to keep a revenue-losing facility from closing altogether.)

At a larger scale of explanation, the Camp Dining Hall’s “death by insignificant increments” might indicate that Barrow’s population grew past a certain size, beyond which its numbers overwhelmed the unifying sense of belonging to an outpost or camp. With less camaraderie-of-adventure to play to, NARL Mess Hall traditions lost some of their appeal and marketability.

At the largest scale of passive causes for the wane of the dining hall at NARL, perhaps older generations’ habits are disappearing: cross-cultural fondness for sharing food in lively company could be a doomed custom. Perhaps cafeteria-style facilities that act as social hubs are a species falling victim globally to

LANE FRANICH, FRIEND TO NARL'S CHILDREN

In the late 1970s, visitors to the NARL Mess Hall, especially for the evening meal, may have noticed that the NARL children (about ages 6-16) would almost always seat themselves facing the entrance. This seemingly odd seating choice was to get the best view of one of their favorite characters when he arrived to dinner. This favorite of the children was Lane Franich, an ITT employee. Lane was well recognized for his comic behavior, which seemed to erupt from time to time. Probably his most famous stunt (in the eyes of the children) was occasionally executed on his entry into the mess hall. While walking down the aisle between dining tables, he would say hello to the kids as he passed each one, and then would tumble to the floor as though he had tripped. His brief but noisy roll on the floor surprised unwary adults, but brought all of the kids to their feet with laughter and shouts of "hey Lane, do that again." At the end of his dramatic tumble on the floor, Lane would calmly pick himself up and keep walking, all the while keeping a straight face. Witnesses of all ages had to wonder how he could fall with such force and noise without getting hurt. He seemed to get a kick out of causing the children to laugh. A fine person and great friend of the youngsters growing up at NARL, Lane passed from the ranks of active NARL alumni a few years ago, as the result of an accident.

—Tom Albert

competitors for everyone's limited time—fast-food consumerism, automation, cable TV, cellular telephones, personal computers—making UIC-NARL's decline just one casualty in a global species-extinction.

Why shouldn't ruthlessly efficient vending machines now take over what remains of NARL food service? If an outcry greeted this proposal, the college could discount it as nostalgia for an era that should be as firmly laid to rest as the Age of Steam. I had nearly succumbed to deciding that the NARL Camp Dining Hall's decline was inevitable—a frayed thread in a bigger fabric worn thin by technological and social change.

Suddenly, a living specimen jolted that bleak assessment with a full-blown flashback of the NARL Camp Dining Hall in robust health. For impact of this flashback, imagine tropical rainforests and polar ozone holes restored. Others can find the NARL Camp Dining Hall of the 1970s restored, as I did in 1998, next to the village of Nuiqsut on the Colville River delta.

More than just a facility that feeds people, Nuiqsut Constructors' new dining hall (a joint venture of Kuukpik Corporation) serves as nerve center for activities around the community. Folks drop in to share coffee, catch up on news, clarify objectives and tasks, and to strike the deals that enable them to achieve things (Fig. 5). The chef and staff at Nuiqsut's dining hall naturally join many of these conversations. They are entrusted with messages. Who better, or more centrally placed, to share vital information about comings and goings of people, vehicles and airplanes? Meal hours are excuses for get-togethers that often stretch into conferences among crew chiefs and work-

ers rotating on and off their shifts. The atmosphere tingles with that sense of adventure, once familiar at NARL.

As a public facility, moreover, Nuiqsut's dining hall seems to be headed on a course opposite to that of Barrow's facility at UIC-NARL. Families from the community are increasingly attracted to use this dining hall as they learn how welcome they are (see text box: "Dinosaurs in the Dining Hall"). Padlocks on coffeepots are unknown. Guests are not treated as loiterers the instant the big hand passes some arbitrary point on a clock face. Coffee and snacks are available round the clock, giving this nerve center the atmosphere of a "people magnet." As such, it seems to be thriving on some underlying unity of purpose. Although Nuiqsut's pursuits today differ from NARL's decades of support for scientific investigations, the differences are only skin-deep. Deeper similarities between two dining halls at peak popularity are impressive. Today's bustling Nuiqsut camp illustrates how



Fig. 5. Strategy session between meals in the Nuiqsut Constructors' dining facility, April 1998. Facing camera, left-to-right: George Woods, Thomas Napageak, and Lanston Chinn of the Kuukpik Corporation.

DINOSAURS IN THE DINING HALL

Beginning in 1991, people of Nuiqsut—especially the youngsters—looked forward at the end of each summer to hearing from paleontologists, and examining dinosaur fossils that the University of Alaska Museum’s expeditions had found during the annual Colville River excavations. The school hosted show-and-tell events in one form or another. Just before NARL’s 50th Anniversary celebrations in Barrow in 1997, we staged an evening “fossil fair” in the Nuiqsut Trapper School Gymnasium, alongside British Petroleum’s exposition of that company’s latest offshore development projects. In August 1998, however, Trapper School was unavailable while its new wing was under construction. Hating to disappoint Nuiqsut youngsters, I cautiously approached the Nuiqsut Constructors’ Camp Manager, to see if we might stage a community show-and-tell in the camp’s new dining hall. The Camp Manager promptly reassured me that he’d be delighted to host the proposed event. “No inconvenience at all,” he said. “Set yourselves up with couple of our tables. And if kids do track in a little mud and ask for ice cream, don’t worry; the more the merrier. We’re here for the community.” Word of the event circulated around Nuiqsut by CB radio. A steady stream of families filed into the dining hall to admire 70-million-year old dinosaur bones. Many stayed for dinner and beyond.

—Dave Norton

cafeteria-style dining supports cohesive social functions in the North. Alaska’s roadhouse tradition has rekindled itself on the Colville delta.

So the species remains as viable now as it was 50 or 100 years ago. Vigorous community enterprise and hospitality of the camp dining hall naturally thrive together in Nuiqsut. Besides Nuiqsut, other healthy examples of the species are reported at Wainwright (R.S. Suydam, pers. comm. 1998) and at Kluane Lake Research Station in Canada’s Yukon Territory (Robinson 1998: iii). These examples suggest that an isolated misfortune is playing itself out in Barrow as a result of local causes. Could it yet pull itself back from the brink? Its rescue seems unlikely unless the issuing of perfunctory doses of food is replaced by a more ambitious vision of its importance to the community.

If Barrow, UIC-NARL, and research funding agencies seek resurgence in arctic investigator-support by the community, planners might consider facilities that include deliberate revival of the Alaska roadhouse tradition. Quakenbush (this volume) shows that the ARF (Fig. 6) maintains convivial traditions at the NARL Camp. Further, by restoring some of the graphic reminders of adventures, and even ‘merciless’ NARL humor (Fig. 7) to walls in whatever becomes the Camp Dining Hall, a facility could begin to reclaim its function as soul of a “university in a Quonset hut.”

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Fig. 6. Signs salvaged by Dr. Tom Albert from demolition of NARL’s former Camp Dining Hall in Quonset Hut # 50 now bracket the entrance to the kitchen at the Arctic Research Facility (ARF) in Building # 350. Dr. Menghua Wei, visiting academician and author from the Peoples’ Republic of China is one of dozens of scientists hosted each year by the North Slope Borough’s Department of Wildlife Management at the ARF.



Fig. 7. Cartoonist's irreverent view of NARL's intrepid R4D aircraft: one of many framed pictures still maintained in the Science Wing of Building #360. Drawing by L. Dickerson (after Spanfeller). Photo, courtesy of D. Ramey and J. C. George.

Chukchi Sea Oceanography: Regional and Global Issues

Thomas Weingartner¹ and J. C. "Craig" George²

ABSTRACT: Researchers find a natural geographic and interdisciplinary focus for regional and global concerns in processes taking place on the broad shelf of the Chukchi Sea, west and southwest of Barrow. Net water and ice movement from the Pacific to the Arctic Ocean take place through the Bering Strait, but local eddies and reversals of this generalization can be significant biologically and to matters related to global change.

Key Words: Arctic Basin, halocline, ocean circulation, Barrow Canyon, Post Office Point, East Siberian Sea, Fram Strait, Bering Strait, sea ice distribution, river discharge, pollutant transport, global change

INTRODUCTION

In the decades following World War II, national security issues provided most of the research motivation in arctic oceanography. With the end of the Cold War pollution and climate change issues redirected the national research agenda. Climate research focuses on understanding the role of the Arctic Ocean in climate and the response of the arctic environment to global change. Arctic industrial development and revelations of massive dumping into the rivers and arctic seas of radionuclides by the former Soviet Union provided a further impetus for oceanographic study. Although the climate and contaminant subjects are disparate in many ways, each requires an understanding of the processes controlling ocean circulation and seawater property modification. These topics are the focus of our research in the Chukchi Sea and they bear on problems of both global and regional concern. We start our discussion with a broad overview of issues having global ramifications and then proceed to highlight topics relevant to the Chukchi Sea. Along the way we point out connections between problems on a global scale, and local interests such as whale feeding areas, sea ice extent, and stability.

ARCTIC BASIN

We begin by noting that the Arctic Ocean occupies only a small fraction of the global ocean: 5% of the surface area and 1.5% of the volume. There is widespread belief, however, that the Arctic Ocean exerts a disproportionately large effect on Earth's climate and that this influence is mediated by two principal mechanisms. The first is the ice distribution (thickness and concentration), which affects the surface albedo and

the flux of heat and moisture between the ocean and the atmosphere. The second is through control on the strength of the thermohaline component of the global ocean circulation. (The thermohaline circulation arises as a consequence of global scale variations in the temperature and salinity distribution of the ocean.) That circulation includes the meridional overturning cells of the mid-latitude ocean basins that are responsible for the climatically important poleward heat flux from tropical latitudes. (The meridional circulation involves sinking and equatorward spreading of water at high latitudes, which is compensated for by upwelling and polar flow at lower latitudes.) The engine driving this heat flux is primed by the sinking of surface water to great depth in the Greenland Sea at the northernmost margin of the Atlantic Ocean. This process of deep-water formation depends sensitively on the salinity of the water exported from the Arctic Ocean into the North Atlantic Ocean (Aagaard et al., 1989). (Nearly all of the ice and water exported from the Arctic Ocean enters the Atlantic through Fram Strait into the Greenland Sea or through the Canadian Archipelago into the Labrador Sea.) Because much of the freshwater of the Arctic Ocean is stored as sea ice, changes in the surface heat budget of the ice could lead to changes in the rate of freshwater export into the Greenland Sea.

The present day distribution of sea ice is linked to the temperature and salinity structure of the Arctic Ocean's upper 800 m, which consists of three distinct layers:

1. A shallow (~50 m deep) surface (or mixed) layer with near-freezing temperatures and low-salinities. Because there is sufficient energy for mixing, heat, salt and other water mass properties are efficiently transferred

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between the underside of the ice and the bottom of the mixed layer. Mixed layer water properties reflect the effects of freezing and thawing and the large amount of river water discharged from the surrounding continents. That discharge is immense and represents 10% of the global river runoff (Aagaard and Carmack, 1989).

2. The halocline which lies below the mixed layer and spans depths between 75 - 300 m. Salinities (and therefore seawater density) increases rapidly across the halocline although temperatures are nearly constant and close to the freezing point.
3. Beneath the halocline is a thick layer that extends from 300 - 800 m depth and with temperatures 2 - 3°C above freezing. This water mass, which originates in the Atlantic Ocean, enters the Arctic Ocean through Fram Strait (a ~3000 m deep passage in the northern Greenland Sea). The Atlantic Water Layer is a vast reservoir of heat that if made available to the mixed layer could lead to an ice-free Arctic Ocean. The thermohaline structure of the halocline effectively inhibits the upward diffusion of heat from the Atlantic Layer and thereby maintains the present-day distribution of sea ice.

Oceanographers have long-recognized that halocline source waters originate on the continental shelves surrounding the Arctic Ocean (Aagaard et al., 1981). The halocline contains clear signatures of shelf processes in the temperature and salinity relationships and in the biogeochemical characteristics. Moreover, the biogeochemical data clearly indicates that the halocline is an amalgamation of water masses contributed from the different shelf seas (Jones and Anderson, 1986; Wilson and Wallace, 1990). Atlantic water modified by freezing and cooling on the Barents and Kara Sea shelves enters the halocline in the Eurasian Basin of the Arctic Ocean (Schauer et al. 1997). Additional shelf water masses might also be injected into the halocline along the margins of the Laptev and East Siberian seas. An eastward flowing current adjacent to the continental slope (Aagaard, 1989) subsequently transports Eurasian halocline waters (along with Atlantic Water) into the Canada Basin (including the Beaufort Sea). There are additional contributions to the halocline from the shelves of the Beaufort and Chukchi seas.

The inflow from the Chukchi shelf consists of Pacific

Ocean waters that flow northward through Bering Strait and across the Chukchi shelf. Pacific waters are important to the Arctic Ocean because they thicken the halocline of the Canada Basin and are an important source of plant nutrients to the Arctic Ocean (Carmack et al., 1986). Consequently this basin has stronger stratification and is capped by thicker ice than the Eurasian Basin. Although oceanographers have been able to identify several of the shelves where halocline source water is formed, they lack a detailed understanding of the mechanisms involved in its formation, and its transport into the central ocean. These are important issues for understanding how the Arctic Ocean functions. We illustrate this point in the following discussion of the regional oceanography of the Chukchi Sea.

CHUKCHI SEA

The inflow of Pacific Ocean water through Bering Strait profoundly influences the circulation, sea ice distribution, water properties, and biology of the Chukchi Sea and as a consequence, the Chukchi shelf is unique among arctic shelf seas. Continuous current measurements over the past ten years in Bering Strait indicate a mean annual northward transport of $8 \times 10^5 \text{ m}^3 \text{ s}^{-1}$ (Roach et al., 1995 and unpublished data)- about 60 times greater than the maximum monthly discharge of the Yukon River. This transport is maintained by the pressure gradient between the Pacific and Arctic oceans. (Sea level in the Pacific Ocean stands higher than sea level in the Arctic Ocean resulting in northward transport through Bering Strait. This sea level difference is a consequence of the global circulation systems alluded to above.) Variations about the mean are large, primarily wind-driven (winds from the north reduce or even reverse the flow), and occur over a time scales ranging from the synoptic (2-10 days) to the interdecadal. For example, changes in transport of from $40 \times 10^5 \text{ m}^3 \text{ s}^{-1}$ northward to $20 \times 10^5 \text{ m}^3 \text{ s}^{-1}$ southward can occur over a period of days (Roach et al., 1995). A portion of the Bering Strait transport flows along the Alaskan coast and enters the Arctic Ocean offshore of Barrow (Fig. 1). There can be similarly rapid changes in speed and direction of the current along the Alaskan coast (Weingartner et al., 1998). There is also a distinct annual transport cycle with the maximum mean monthly transport in summer ($14 \times 10^5 \text{ m}^3 \text{ s}^{-1}$) and the minimum mean monthly transport in winter ($3 \times 10^5 \text{ m}^3 \text{ s}^{-1}$). Interannual variability is also high with a range of about $\pm 5 \times 10^5 \text{ m}^3 \text{ s}^{-1}$. Long-term transport estimates based on the statistical relationships between the regional winds and measured transport suggests that the mean annual transport from 1946-68 was greater than that from the

1970s to the present. Sustained periods (several years or more) of anomalous transport might lead to substantive changes in the stratification and ice thickness distribution of the Arctic Ocean because the residence time of the mixed layer and halocline are only about a decade.

Most of the water flowing through Bering Strait is transported onto the northern Bering shelf from the deep Bering Sea. This water mass is salty and nutrient-rich and it sustains the enormously productive marine ecosystems of the northern Bering/southern Chukchi seas (Walsh et al., 1989). Some of this production settles to the seabed in these areas where it is consumed by benthic organisms (Grebmeier et al., 1988). However a substantial fraction of it is carried northward and either settles over the outer Chukchi shelf or is exported into the Arctic Ocean. The fraction that remains on the shelf sustains the benthic organisms essential to higher trophic levels (walrus, gray whale, bearded seal, arctic and saffron cods and sculpins). The rest of the water flowing through the strait originates on the Bering Sea shelf and it is less saline and nutrient-poor. These water masses largely retain their identity on crossing the Chukchi shelf as they are steered along three prominent bathymetric pathways (Coachman et al., 1975; Weingartner et al., 1999). The most saline and nutrient-rich water is carried westward through Hope Valley and then northward through Herald Valley in the western Chukchi Sea. Some of this water eventually swings eastward across the outer shelf and continental slope. A second branch, of moderate salinity and nutrient concentrations, flows northward along the east flank of Herald Shoal and onto the central shelf. The third branch, of low salinity and low nutrient concentrations, flows northeastward along the Alaskan coast and exits the Chukchi Sea through Barrow Canyon (Fig. 1).

More recent data sets from Bering Strait include measurements of salinity and these reveal large interannual variations in the salinity of the water moving northward through Bering Strait. One implication of this finding is that the depth to which Pacific waters sink upon entering the Arctic Ocean (the ventilation depth) will vary because the ventilation depth is primarily a function of salinity differences between water masses. These variations have important consequences on the fate of dissolved and suspended material advected across the Chukchi Sea. Salinity variations are correlated with nutrient concentrations (Walsh et al., 1989). Hence, the salinity changes imply concomitant changes in the flux of nutrients onto the Chukchi shelf. Such changes could affect the regional biological production.

The Bering Strait inflow also affects the seasonal evolution of sea ice on the Chukchi shelf. The predominant effect is that the ice-free season begins earlier in the spring and extends further into the fall than the ice-free seasons of the Beaufort and East Siberian seas. The three flow branches markedly affect the sea ice distribution by creating a system of ice-edge embayments that extend across the Chukchi shelf. These embayments, which are a consequence of melting due to the advection of heat from the Bering Sea, were well-known to the New England whalers of the 19th century (Bockstoe 1986:54). The whalers routinely used “post-office point”, the persistent ice tongue in the central Chukchi Sea, as a rendezvous point for vessels transiting to and from the Western Arctic whaling grounds.

Various processes modify the Pacific Ocean water as it flows across the Chukchi Sea. Many of these entail mass and energy exchanges with the atmosphere, ice, seabed, and other water masses on the shelf. We will consider three of these processes

- salinization due to brine rejection from growing sea ice;
- mixing of the Bering Strait inflow with river water in the western Chukchi Sea;
- and upwelling along the continental shelfbreak.

When seawater freezes most of the salt is rejected from the sea ice lattice (Martin and Kaufmann, 1981). If the water depth is shallow and ice production vigorous, the salinity (density) of the underlying water column can rapidly increase (Gawarkiewicz and Chapman, 1995). Ice production results in the formation of very cold and salty water masses that affect mixing, the transport of shelf waters into the ocean interior, and the maintenance of the halocline. Conditions suitable for the production of dense water often occur in early winter along the northwest coast of Alaska (between Cape Lisburne and Barrow) when offshore winds cause vast stretches of open water (polynyas) to form along the coast (Cavalieri and Martin, 1994). We find that most of the dense water formed here flows down Barrow Canyon and mixes only slightly with ambient seawater. Some of this water is dense enough that if it does not mix as it flows across the shelf and slope it would sink to the bottom of the Canada Basin (Weingartner et al., 1998). We also find that some of the dense water moves across the shelf as bottom-confined eddies (Gawarkiewicz and Chapman, 1995; unpublished data of Weingartner).

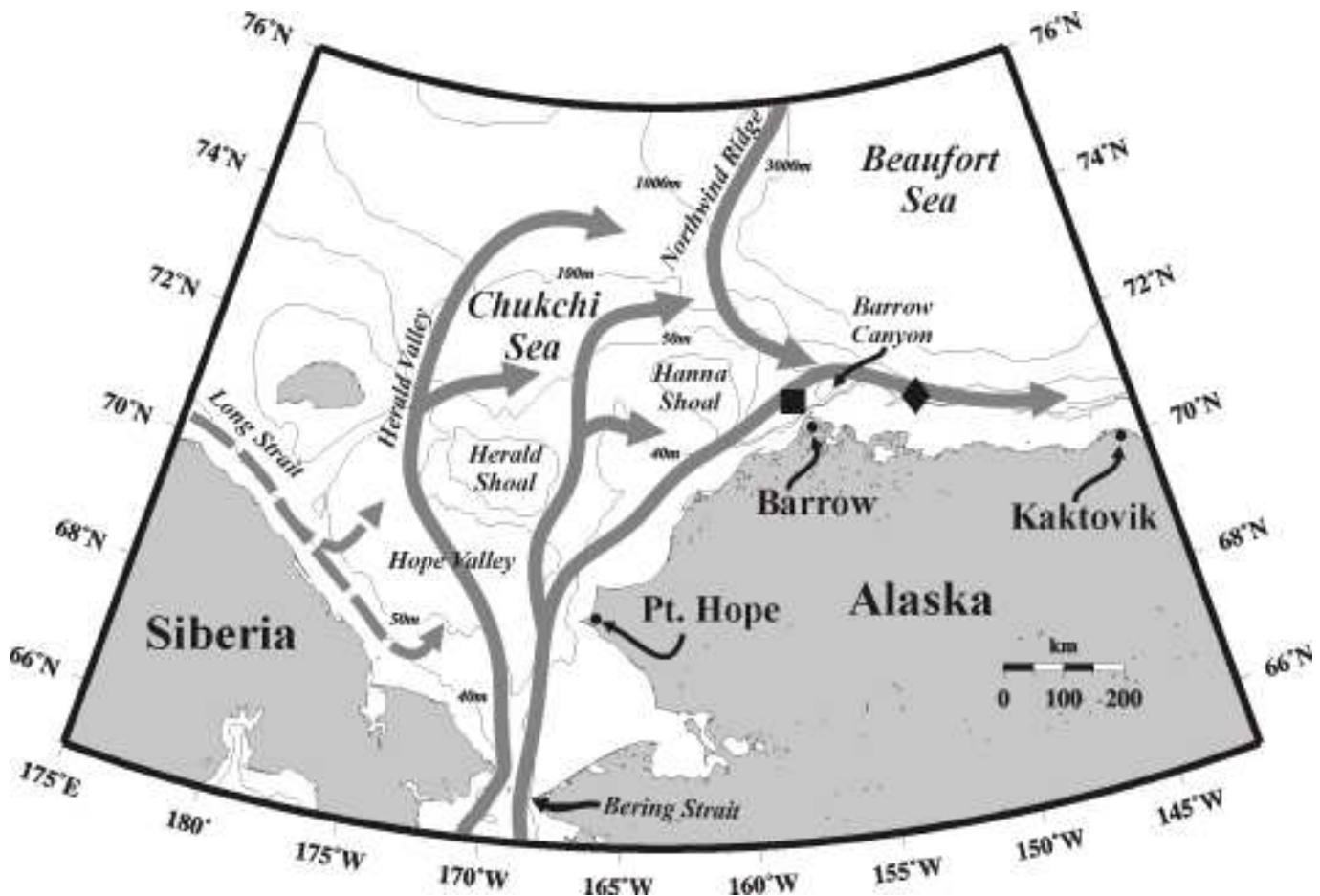


Fig. 1. A schematic of the Chukchi Sea circulation depicting the pathways of Pacific Ocean water flowing across the shelf and emptying into the Arctic Ocean along the Chukchi-Beaufort shelfbreak. The Pacific outflow from the Chukchi shelf enters the Arctic Ocean at depths shallower than the Atlantic Water depicted in this schematic by the arrow extending southward along the Northwind Ridge. The solid arrows imply that these currents are permanent features of the flow field. The dashed arrow along the Siberian coast represents the Siberian Coastal Current, which flows seasonally in late summer and fall but is probably absent in winter and spring.

These eddies might be the precursors to the ubiquitous eddies that populate the Arctic Ocean (Manley and Hunkins, 1985; D'Asaro, 1988). We suspect that these processes are probably occurring to some extent on other arctic shelves as well. The eddies might be an efficient transport mechanism by which pollutants released from the seabed can be transported into the boundary currents flowing along the continental slope.

The Chukchi Sea also receives water from the East Siberian Sea primarily via the Siberian Coastal Current, which enters the Chukchi Sea through Long Strait (Coachman et al., 1975; Weingartner et al., 1999). The Siberian Coastal Current transports river waters from the Indigirka and Kolyma rivers in the East Siberian Sea and possibly from as far west as the Lena River from the Laptev Sea. The eastward flow of the current is a consequence of river discharge and the Coriolis effect. This current has the potential to transport

dissolved and suspended materials from along a vast stretch of Siberia into the Chukchi Sea. Although some Siberian Coastal Current water is carried southward through Bering Strait, most of it is mixed with ambient Chukchi Sea water before reaching the strait. Mixing is primarily accomplished by meanders and eddies which form along the front separating the coastal current from ambient shelf water. In some years, however, this current is absent in the Chukchi Sea and we believe that this is a consequence of unusual wind conditions.

Bowhead whales are often observed in the Siberian Coastal Current (Moore et al., 1995) apparently feeding on dense aggregations of zooplankton formed as a consequence of strong cross-shore flows associated with the current. However, in 1995 the coastal current was absent from the Chukchi Sea due to steady winds from the southeast. Consequently the physical mecha-

nisms conducive to zooplankton aggregation were non-operant and we did not observe bowhead whales within the Siberian Coastal Current in September 1995, although they were observed in 1992 and 1993 when the current was present. (Another important fall feeding area is in the vicinity of Cape Serdtse-Kamen according to Native Chukotka observers. Flow around the cape might cause dense aggregations of zooplankton.)

Arctic Ocean waters can also be transferred onto the shelf by a process called upwelling in which waters are lifted vertically and then transported horizontally onto the shelf. Upwelling is often induced by the wind although the location of the upwelling event might occur far from the wind system that instigated the ocean response. Episodic upwelling events lasting 2 - 10 days, occur along the Chukchi and Beaufort shelfbreaks throughout the year but most frequently in fall and winter when winds are most variable (Aagaard and Roach, 1990). Onshore transport associated with upwelling is most efficient within the canyons that indent the continental slope. For example, we have observed upwelled Atlantic Water at the head of Barrow Canyon in 70 m water depth implying that this water was lifted vertically by about 230 m and carried more than 100 km along the length of the canyon (Weingartner et al., 1998). The onshore flows associated with upwelling are very swift and often exceed 1 m s⁻¹ (2 knots). Upwelling represents one means by which halocline water might form because the upwelled slope water usually mixes with shelf water before being swept back into the ocean. Upwelling also represents a mechanism by which pollutants carried at depth within the eastward flowing boundary currents can be transported back onto continental shelves far from the point where they were initially discharged.

The results of many years of fruitful and enjoyable collaboration with Knut Aagaard are reflected in this paper. Our research has been supported by numerous agencies over the years. The North Slope Borough has provided financial support to JCG and extensive logistical support and encouragement to both of us. Financial support for TW has been provided by the National Science Foundation, the Coastal Marine Institute of the Minerals Management Service, the Office of Naval Research, and the National Aeronautics and Space Administration. Finally, T. Tokizawa and Y. Sasaki of the Japan Marine Science and Technology Center (JAMSTEC) have been valued collaborators in our research programs.

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Vegetation Research and Global Change at Barrow

Patrick J. Webber¹ and Robert D. Hollister¹

ABSTRACT: Barrow's northerly location and climate provide a special opportunity to study arctic terrestrial plant ecology. Although NARL-based studies capitalized on this opportunity, the type of and rationale for botanical research at Barrow have changed over the 50 years since NARL began. Studies have changed from a focus on description and the study of plant distribution to one of understanding how the system is changing in response to the pressures of land use, land cover change, and climate change. Current goals of vegetation research at Barrow include predicting future vegetation cover in terms of its value to sustain landscape integrity and the organisms that depend on plants for food and shelter. Major contributions to Arctic Botany made possible through the base and logistics support of the NARL include those by Maxwell E. Britton, Larry L. Tieszen and W. Dwight Billings and his students from Duke University. Current and ongoing efforts to meet the challenge of a changing Arctic, many of which are sponsored by the Arctic System Science (ARCSS) Program of the Office of Polar Programs, National Science Foundation are discussed. Early results of the International Tundra Experiment (ITEX), in which various vegetation types are subjected to warming to simulate climate warming, are provided that suggest that the Barrow vegetation will increase in stature and productivity with warming. Future vegetation research at Barrow will likely focus on the special opportunities presented by the Barrow system such as the consequences and needs of the growing city and its citizens and its special environmental setting and constraints. This research will contribute to understanding the Barrow system and the whole Arctic System.

Key words: Arctic ecosystems, Arctic System Science, Arctic vegetation, Barrow Environmental Observatory, climate change, global change, International Tundra Experiment, ITEX, research history.

INTRODUCTION

Compared to some celebrants of 50 years of research associated with the Naval Arctic Research Laboratory (NARL) we are relative newcomers. The senior author arrived here in 1971 as part of the U.S. effort in the Tundra Biome Program of the International Biological Program (IBP) program (Brown *et al.* 1980; this volume) and the junior author (RDH) started in 1995 as project manager of the Barrow site of the International Tundra Experiment (ITEX) (Henry and Molau 1997). With the inevitability of age one of us will be retiring from academic life in the not too distant future, whereas the other has every intention of a career-long affiliation with Barrow. PJW joined the IBP effort at the invitation of Jerry Brown and brought with him experiences and biases from his research in Baffin Island and Hudson Bay (e.g., Andrews and Webber 1964; Webber *et al.* 1970; Webber 1971) and RDH participates in ITEX as part of his graduate research program (Hollister 1998; Hollister and Webber 2000). Barrow and its citizens have been generous to us. We hope to demonstrate in this presentation that the Barrow environment continues to offer the opportunity to understand Nature in the Arctic and to do research related to real world problems especially those that challenge its citizens.

The vegetation of any area is the foundation of the integrity and function of its ecosystems. Most notably, the plants that comprise the vegetation are the source of energy and nutrition for food chains, agents for soil stability, and determinants of local hydrology. The importance of vegetation was known to the sponsors of research at NARL and was the basis for the inclusion of botany along with the wide array of basic and applied research undertaken over the years (Reed and Ronnhovde 1971). Contributions that can be made by plant scientists working at Barrow remain as significant as ever in the era of UIC-NARL; these contributions will build on the foundations laid by the pioneering botanists whose work was made possible by the existence of NARL.

THE BARROW SETTING, GLOBAL CHANGE AND RESEARCH THRUSTS

Botanical research at Barrow, while important to local ecosystem integrity and change, is most valued for its contribution to Arctic science as a whole. The special climatic, physiographic and human dimensions coupled with the rich research heritage of Barrow allow analysis and understanding of the consequences of global change that would be difficult to do elsewhere. Here we define global change as natural and human-induced change of Earth system

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processes and interactions. In particular we emphasize climate change, land use and land cover change.

The Barrow peninsula, which juts into the Arctic Ocean, is situated at the northernmost tip of the Arctic Coastal Plain of Alaska, has long, dry, cold winters and short moist, cool summers (Brown *et al.* 1980). This climate, combined with the flat landscape and a preponderance of wet acid soils, leads to a low biological diversity, low plant productivity, and low rates of development or recovery when compared to other arctic Alaskan coastal sites. Edward Clebsch (1957; Clebsch and Shanks 1968), working from Barrow southwards and inland to what was then called Meade River (now Atqasuk, previously spelled Atkasook) first documented the increasing floristic richness and vigor of the vegetation along the 100-km (60-mile) gradient of increasing summer temperature and greater landform diversity. Barrow is often assigned to the High Arctic biogeographic zone because erect plant forms are rare and restricted to sheltered, warm spots. At Atqasuk, erect shrubs may be found on normal sites, thus this region is considered to belong to the Low Arctic (Murray 1978). This special character of the Barrow tundra was clearly described by John Cantlon (1961). He called this tundra type “Littoral” and plotted it along the Arctic Ocean Coast of Alaska. The southerly limit of the Littoral Tundra has been correlated with the mean July isotherm of 7°C (Haugen and Brown 1980). The mean July temperature at Barrow is 4°C and at Atqasuk it is estimated to be 8°C (Haugen and Brown 1980). Therefore, the Barrow-to-Atqasuk transect represents an ideal setting to study the biological implications of differing climatic regimes across an otherwise relatively similar landscape.

The climatic control of the tundra system raises the question of what will happen to life around Barrow if the predicted warming of the Arctic by “greenhouse” mechanisms (International Panel on Climate Change 1996; Maxwell 1997) occurs. We cannot fully answer this question yet, but can reasonably assume that there would be changes. We continue to work on the magnitude and direction of such potential changes. Already, we are certain that the annual temperature of the Western Arctic—which includes Barrow—has warmed in recent years by at least 1°C (or nearly 2°F) (Chapman and Walsh 1993) and we also know that snow melt occurs earlier at Barrow (Dutton and Endres 1991) and that the urban winter temperature is warmer by about

4°C (Dan Endres, personal communication). None of these reliable observations can be firmly linked to greenhouse warming. The observed regional warming may be part of a natural cycle; moreover, local warming may be the result of an “urban heat island effect”. Regardless of the cause the reality of warming and its consequences remain.

Another part of global change is land use and land cover change. The condition and use of the land in the Barrow Area has changed dramatically since the early days of NARL. This is almost wholly a result of the growing human population and expanding civil infrastructure and may be seen as a more direct and immediate threat to the Barrow system than climate change. While Barrow-based observations and historical records on the effects of surface disturbance on the vegetation are available (see Webber *et al.* 1980) much remains to be done and it is important that future research address cumulative effects of environmental impacts (see Walker *et al.* 1986) and synergism between surface alteration and climate change. The issue of surface disturbance will not be explored further in this paper but is highlighted as an important area for future Barrow-based research since there is a growing pressure upon plant and animal life and other renewable resources brought about by increasing use of a limited land base.

Vegetation research at Barrow and the vicinity of Barrow (e.g., at Atqasuk) reached its zenith in the 1970s with the IBP (see Tieszen 1978a; Brown *et al.* 1980) and the RATE (Research on Arctic Tundra Environments) program (see Batzli 1980) and declined through the 1980s and most of the 1990s. The downsizing of NARL and the desire by researchers to study new systems beyond the Barrow horizon caused this decline. A new center for Alaskan arctic research emerged at the Toolik Lake field Station where scientists who, in many instances, served their apprenticeships at Barrow have made great progress. These included Gus Shaver, Terry Chapin and Skip Walker (see *inter alia*, Chapin *et al.* 1992; Shaver *et al.* 1990; Walker and Walker 1991). Notable activities based at Toolik Lake are the LTER (Long-Term Ecological Research) project (Shaver 1996), the R4D (Response, Resistance, Resilience, and Recovery from Disturbance) program (Reynolds and Tenhunen 1996) and the LAII (Land Atmosphere Ice Interactions) activities (Arctic System Science 1997). These studies have included population and process studies but have stressed the need to study whole regional landscape

systems and indeed to view these systems as part of a whole interacting Arctic System (Oechel *et al.* 1997).

The success of research at the Toolik Lake field Station does not imply that scientists no longer wish to study at Barrow. On the contrary, there is a resurgence of plant science in response to the realization that Barrow offers a special setting for plant research and that in order to understand the whole Arctic System research cannot be confined to one place. The Barrow area is special in its biogeographic position, research heritage and human dimensions. The resurgence of terrestrial research at Barrow has also been aided by the opportunities for research funding provided by the National Science Foundation (NSF) Arctic System Science (ARCSS) Program. This program emphasizes the changing Arctic as a whole system that includes humans. ARCSS is part of the U.S. Global Change Research Program. Public opinion has also assisted in the resurgence of terrestrial research in the Barrow Area. The citizens of Barrow highly value research and consider it part of the community's heritage as clearly seen in these proceedings. The establishment of a 3,000-hectare permanently protected research area, known as the Barrow Environmental Observatory (BEO), has assured the opportunity for continued long term terrestrial research in the Barrow Area.

MILESTONES IN BARROW VEGETATION SCIENCE

Past botanical research at Barrow has been thoroughly documented by Britton (1957), Johnson and Tieszen (1973), Webber (1978), Shaver (1996) and Brown (this volume). Nevertheless to support our thesis concerning future directions for vegetation science at Barrow we present a brief overview of past and present directions with some selected milestones. These we list in a sequence of activities that mirrors the development of ecology from the description of components and their life cycles through the study of process and ecosystem function to studying the dynamics and human dimensions of the whole Arctic System. This interpretation is not meant to rate one emphasis or goal over another. Indeed description of ecosystem structure and research on ecosystem process will remain the foundation for Arctic System research.

Description. This began with the establishment of NARL. Ira Wiggins (1951) described the distribution of plants on the main types of ice-

wedge polygons. Eric Hultén (1951) included Barrow vascular plants in his listings for Alaska and made several visits to Barrow over the years. Edward Clebsch's (1957) gradient description was mentioned earlier. In our view the most important botanical contribution was made by Maxwell E. Britton (1957) whose widespread travels set the Barrow vegetation into perspective with the entire North Slope. Britton made the first comprehensive description of the major landscape process of the Arctic Coastal Plain, which he called the "Thaw Lake Cycle". Later authors embellished this cycle (e.g., Webber, 1978, Walker *et al.* 1980, Billings and Peterson (1980) with inferred plant succession pathways and estimates of rates of development but the original mechanism and dynamic as described by Britton remains accepted. Webber (1978) described for the IBP study area (see Brown this volume) the principal plant communities and their environmental controls and production. Elias *et al.* (1996) described the botanical history, vegetation, and diversity of the area adjacent to the BEO. The latter two studies left permanently marked quadrats and transects against which future changes could be compared. We can assert that nowhere else in Alaska is the flora as thoroughly known as that of Barrow. Murray and Murray (1978) compiled a thorough checklist of the plants of the Barrow area. It is based on the collections of many specialists who visited NARL (e.g., *inter alia*, Eric Hultén - vascular plants, William C. Steere and James E. Rastorfer - bryophytes, Emanuel D. Rudolph and John W. Thompson - lichens). The higher fungi have been well documented by Orson K. Miller and Gary A. Laursen (Laursen and Ammirati 1982; Laursen *et al.* this volume).

Ecosystem Analysis. Plants interact amongst themselves and with other living and non-living components of their environment, thus if we are to know their future state we must study them as components of a whole interacting ecological system that is the ecosystem. The research conducted during five years (1970-1974) under the IBP during the zenith of the NARL was integrated around understanding the wet tundra ecosystem at Barrow. The goal of the IBP Tundra Biome program was to describe, measure, understand, and model the wet tundra in order to address the problems of its maintenance and restoration (Brown this volume). While it never fully reached its lofty goal it is fair to say that the new understanding laid the foundation for most ensuing North Slope and other arctic ecological research. IBP did not pioneer tundra

ecosystem research, rather it built upon the efforts of predecessors including Frank Pitelka (1957) and Arnold Schultz (1964). Pitelka and Schultz described the essential interactions between the plants, minerals, and animals of the Barrow ecosystem and postulated the “Nutrient Recovery Hypothesis” to explain tundra animal cycles. This hypothesis became one of the foci of the IBP and subsequent RATE effort at Atkasuk (Batzli 1980). Another pre-IBP ecosystem program that benefited by NARL logistics support was the Cape Thompson Project (Wilimovsky and Wolfe 1966). This project was designed to gather baseline descriptions and ecosystem dynamics prior to a proposed, but never consummated, nuclear explosion to excavate a potential harbor on the Chukchi Sea coast near Point Hope. The Cape Thompson Project was more descriptive and less process-based than IBP, nevertheless it took a whole system view and included human dimensions that were largely lacking in IBP except for a general treatment of vegetation and land surface disturbance from off-road vehicles and oil spills (Challinor and Gersper 1975; Everett 1978; Webber *et al.* 1980). Larry L. Tieszen who edited the substantial book “Vegetation and Production Ecology of an Alaskan Arctic Tundra” coordinated the plant and vegetation investigations of the IBP (Tieszen 1978a) to which 44 authors contributed. These findings were later combined into the Barrow ecosystem synthesis volume with 56 contributors and edited by Brown *et al.* (1980). The IBP plant and vegetation studies focussed on the controls and magnitude of primary production. It is the energy and minerals captured by plants that drives the rest of the ecosystem. The pioneering efforts in these studies included the use of ecophysiology and plant population biology to understand plant growth. Such studies were made possible only by the NARL facility that was able to supply reliable electric power, small portable buildings, and permanent laboratories equipped with instruments such as balances, autoclaves and scintillation counters. Tieszen (1978b) studied the photosynthesis of the major vascular plants under varying light and temperature conditions. He established that maximum photosynthetic rates were comparable to plants in the temperate zones, but ecosystem productivity is limited due to a short growing season that does not effectively begin until snowmelt and then only a week to ten days before the summer solstice (Figure 1). Walter Oechel and Bjartmar Sveinbjörnsson (1978) studied moss photosynthesis and established that mosses, in appropriately moist situations contribute nearly as much to overall energy

capture as the vascular plants. The IBP plant study effort emphasized the importance of soil nutrients on tundra primary production (Chapin 1978) and the importance of the growth of belowground plant structures where the living material is commonly 10 or more times that seen aboveground (Webber and May 1977). Regarding the latter Billings, Peterson, and Shaver (1978) examined the rooting systems of three coexisting vascular plants (*Carex aquatilis*, *Eriophorum angustifolium* and *Dupontia fisheri*) and found them to contrast greater in structure and function than their above ground components. The studies of belowground growth and nutrients and the control ecosystem processes and function begun by these scientists at Barrow remain a major focus of these authors and their national and international colleagues at sites beyond Barrow as exemplified by the many papers on this subject in Chapin *et al.* (1992), Reynolds *et al.* (1996) and Oechel *et al.* (1997).

The ecosystem research of Walter C. Oechel and his colleagues from San Diego State University is particularly notable. This contribution has two aspects; first, in the early 1990s he brought plant scientists back to Barrow after a hiatus of 15 years; and secondly, he was the first to address at Barrow the local response of the vegetation to possible greenhouse warming via atmospheric carbon dioxide (CO₂) enrichment. The focus on greenhouse warming and climate change represented a real cultural shift in Arctic plant science. During IBP, despite the plethora of papers and major advances in understanding photosynthesis and carbon balance in Arctic systems, no mention was made of these topics. They came into focus in the early 1980s when Philip Miller, who was one of the leaders in the Barrow IBP plant science effort, and his colleagues, notably Billings and Oechel, began to address the issue of plant and ecosystem response to elevated CO₂ (Miller 1981, Billings *et al.* 1982). Before returning to Barrow, Oechel had been active at Toolik measuring the response of tundra vegetation to CO₂ enrichment (e.g., Oechel and Strain 1985). His work at Barrow led to some widely cited and intriguing observations on a possible state change from the long-term normal condition of the system as a net sink of carbon to a net source (Oechel *et al.* 1993; 1994; 1995). These reports described observed shifts over two seasons of the summer carbon balance of a moist tundra ecosystem. The cause of this shift is unclear. It might have been the result of drier soil around the IBP site resulting from climate warming or improved drainage. In any

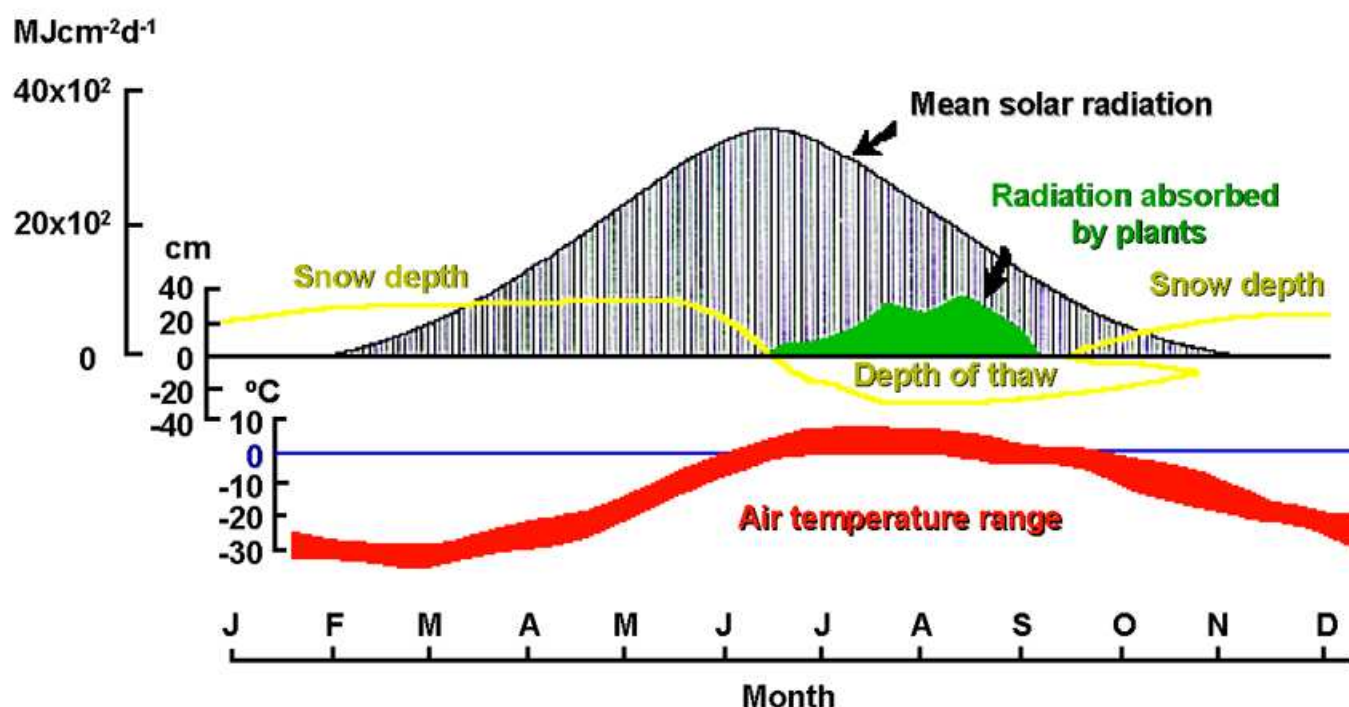


Fig. 1. Diagram showing the mean annual pattern of solar radiation, snow depth, range of air temperature, depth of soil thaw and radiation absorbed by green plants for Barrow. Note that plant photosynthesis, as indicated by absorption of radiation, is limited to the snow free period, does not become significant until after the summer solstice and is restricted to about 90 days (after Chapin and Shaver 1985). It is easy to imagine, from this diagram, that Barrow plants will be affected by earlier snowmelt and increased air temperatures.

event the state change has not been permanent. Nevertheless a phase change of the system from source to sink could have far reaching consequences given the large reservoir of carbon in tundra soils and the present valuable service that tundra vegetation performs in capturing CO_2 . Oechel's work points to the value of long-term environmental monitoring and the need to be aware of the potential for unanticipated results such as the positive feedback between climate warming and the carbon cycle.

Arctic System Science. The above cultural shift toward studying a changing Arctic was aided in the late 1980s with the advent of longer-term funding that supported more continuous observations and experiments over larger spatial scales. This was driven by the realization that the IBP, RATE and R4D research projects were inevitably restricted to the study of short-term phenomena and were not able to meet the need to understand long-term spatial and temporal change in the Arctic because they were only funded for short periods. This shift is exemplified by the LTER research at Toolik Lake (Shaver 1996) that enjoys sustained long-term funding and has allowed Toolik to surpass Barrow as the best known tundra site in the world. Although the LTER model is a continuing success story, its

largely site specific findings make it insufficient to address wider implications of global change. Further, global change research requires a consideration of human dimensions that are neither a major factor at the Toolik site nor a focus of Toolik LTER research. The desire to study whole systems led a group of arctic scientists with help from the University Center for Atmospheric Research and NSF funding to recommend an Arctic component to the International Geosphere-Biosphere Programme (IGBP) (Arctic Interactions 1988). These recommendation guided the NSF decision to launch the Arctic Systems Science (ARCSS) program as part of the US contribution to IGBP in 1989 (Arctic System Science 1990). The proximate goal of ARCSS is to predict the responses of the physical, biological, and social systems within the Arctic to future global changes in order to assist with the formulation of public policy options. The ultimate goal of ARCSS is to predict the future state of the Arctic System (Toward Prediction of the Arctic System 1998). Central to ARCSS is the dogma that the Arctic may be viewed as a single interacting system, which in turn is part of the Earth System. The ARCSS Program is generously funded at an annual rate of more than 15 times that of the IBP program, and has several components which include: past changes, marine

systems, terrestrial systems, human dimensions, and synthesis and modeling (Arctic System Science 1997). Some vegetation research is done in most of these components, but to date most has been supported in the terrestrial systems component that has the formal name Land-Atmosphere-Ice-Interactions (LAII). Overall LAII usually has 2 or 3 integrated projects each with a team of scientists from several institutions. The first LAII team project was called LAII Flux and it concerned the measurement and controls of carbon balance and exchange over the Kuparuk River basin which stretches from the foothills of the Brooks Range to the Arctic Ocean at Prudhoe Bay and includes the Toolik lake watershed (Weller *et al.* 1995). LAII Flux advanced the understanding of trace gas fluxes over large areas (e.g., Nelson *et al.* 1997; Walker *et al.* 1998). LAII also supported a project to examine the sustainability of caribou herds against the dynamics of human use, industrial development, public policy and climate change (Griffith *et al.* 1999) and a study of the Pacific black brant goose in the Yukon-Kuskokwim Delta (Sedinger 1998). Since both caribou and brant are herbivores both studies examined plant growth in terms of climate change and disturbance and included considerations as to the sustainability of the animals of concern (Epstein *et al.* 2000; Person *et al.* 1998). In an attempt to increase the rationale and possible themes for human dimensions of Arctic research a new thrust to ARCSS has been explored via a series of workshops resulting in a new ARCSS component called Human dimensions in the Arctic (HARC) (People in the Arctic 1997). Although the above projects were not carried out near Barrow they lay the foundation for the current Barrow-based vegetation projects outlined in the next section.

CURRENT VEGETATION RESEARCH IN THE BARROW REGION

Nearly all the current vegetation research done in Barrow is in some way linked to an ARCSS project. The longest currently ongoing project in the Barrow area is the ITEX project described below. Several other vegetation studies are being carried out under the second phase of LAII Flux known as ATLAS (Arctic Transitions in the Land-Atmosphere System).

International Tundra Experiment. ITEX examines the responses of individual plant species and their host communities across a network of specific sites that is distributed across the entire Arctic. Presently there are 28 sites in 11 countries

including all 8 Arctic Nations. The goal of ITEX is to improve and quantify the understanding of short-term and long-term responses of tundra plant species and vegetation to annual variation of and increase in temperature (Henry and Molau 1997). A common experiment at all ITEX sites uses small passive open-top chambers (Figure 2) to warm the plant canopy (Molau and Mølgaard 1996). Many ITEX sites have the same species and all sites have the same tundra plant forms. Fieldwork began in Canada and Scandinavia in 1991 although it did not get underway at Toolik, Barrow, and Atkasuk until 1993, 1994, and 1995 respectively. ITEX was formulated in 1990 with the help of many internationally known arctic botanists, several of whom were active in the IBP program (Walker and Webber 1991). The idea for the study was triggered by an interaction that one of us (PJW) had with an unidentified Inuit elder, who following a lecture, given in Ottawa, Canada concerning how climate change might affect Arctic vegetation (Webber 1990), pointedly said “Professor, what you tell us about climate change and release of gases from the tundra is very interesting but can you tell me what will happen to our whitefish, berries and ptarmigan?” In other words, we were ignoring how particular species will respond to climate change. The ITEX approach with its standard networked experiment is one way to obtain the necessary species-specific understanding to address this concern.



Fig. 2. Dr. Jerry Brown, Director of the IBP Tundra Biome program (1969-1974) and expert on soil active layer dynamics assisting with soil probing on the ITEX dry meadow site at Barrow (photo by R. D. Hollister). The plastic small open top greenhouses are used to raise the temperature of the vegetation canopy. Commonly the temperature in the chambers is warmed by an average of 2 degrees centigrade. This leads to earlier flowering and increased stature and seed production in nearly all plants.

The Barrow ITEX site is located in the BEO, and has forty-eight chambers and the same number of control plots arrayed in a wet meadow and a dry heath community (Bay 1995, 1996, Hollister 1998). The preliminary findings to date are that warming increases plant stature and accelerates phenology and early season growth rates but does not consistently increase overall vegetative growth. The chambers are effective at warming plant canopies in a fashion that is commensurate with predicted climate warming; furthermore plant response to chamber warming has been shown to be similar to response to inter annual warming (Hollister and Webber 2000). The first four years of results across the Arctic-wide ITEX network have been pooled (Arft *et al.* 1999). They show that initial response of plants to warming is an increase in growth but later reproductive effort also increases. They also show differences between High and Low Arctic sites with High Arctic sites such as Barrow showing less growth response but more reproductive responses than Low Arctic sites such as Atqasuk. As ITEX continues the plant communities within the chambers will change composition. Chapin and Shaver (1985; 1996) demonstrated at Toolik in an experiment that pre-dates ITEX, that within greenhouses, tussock tundra becomes dominated by shrubs and this changes the structure, function, and value of the vegetation component of the ecosystem. They also pointed out that short-term responses are also different from long-term responses. This supports the need to commit to long term observations and experiments.

The above leads to the speculation that since the summer at Atqasuk is about 4°C warmer than at Barrow and since this amount is similar to that predicted by the climate change scientists for Barrow over the next 50 years the vegetation of Barrow will become more like that of Atqasuk. This is not an unreasonable prediction although the cooling influence of the Arctic Ocean and the low habitat diversity at Barrow will always restrict the variety of plants and the stature of the vegetation to some extent. But we can be assured that if Barrow continues to warm the vegetation will change and we hope that ITEX will help us anticipate the nature of those changes.

CONCLUDING REMARKS

We believe that most future research based at Barrow will have a global change emphasis. Barrow is ideally suited for the study of global change issues for many reasons including: the human component

of the system, the historical research records which serve as a baseline, its climate which is highly susceptible to minor changes in daily temperature and season length, and the steep natural climate gradient from Barrow southward. Furthermore, as researchers attempt more integrative whole system studies, which is clearly the national trend, the demand for Barrow based research will increase because of the potential to study human, land, air, and ocean components of the system in one location. It is certain that vegetation studies will continue to be a major component of these future projects.

Over the past few human generations the City of Barrow, from the point of view of the human condition alone, is among the most changed places on Earth. This will be attested by anyone who witnessed the formation and history of NARL. We think that most people would agree that while most of the changes at Barrow have been beneficial the realities of an expanding city and a shrinking and increasingly changing globe raise the specter of deteriorating local environments and ecosystems. None can be certain of the future but we are quite sure that there will be people in Barrow who want to live nowhere else. Therefore, it is particularly encouraging to see the commitment of the people of Barrow to environmental research and the preservation of the environment. The BEO is testament to this. We applaud the people of Barrow for founding the BEO and urge citizens and scientists alike to use, promote, and secure this investment. From our point of view, as botanists, we can assert that Barrow will remain a useful place to do research on plants. The special environmental and biogeographic setting of Barrow and the resource provided by the BEO and the people of Barrow give us this assurance.

We acknowledge the legacy of plant research that resulted from the pioneering work by Max Britton, Ed Clebsch, John Cantlon, Phil Miller, Larry Tieszen, and Dwight Billings. We are grateful to the NARL alumni Jerry Brown, Steve Maclean, Phil Johnson, Dave Murray, Walt Oechel, Kaye Everett, Bart Sveinbjörnsson, and Gus Shaver who helped develop the idea for ITEX and to Christian Bay and Fritz Nelson who began the Barrow ITEX project. Pat Webber thanks his graduate students Skip Walker, Marilyn Walker, Lisa Walker, Sue Vetter Clark, Vera Komarkova, Diane Ebert-May, Terry May, Jim Ebersole, Rosa Meehan, Nonie Werbe, Lee Klinger and Brian Noyle who spent various lengths of time on the North Slope and who provided the stimulus to persist with inquiry. We are grateful to the people of Barrow who continue to help in many ways. In particular we thank Herman Kignak, Bart Ahsogeak, Charlie Neakok, Glenn Sheehan and Richard Glenn. We acknowledge the financial support provided over a span of thirty years by the National Science Foundation and the U.S. Corps of Engineers. Finally we thank

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Integration of Local Knowledge into Ilisagvik College's Science Curriculum

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ABSTRACT: Locally available resources and resource persons contribute to the context-based educational approach favored by the college science curriculum.

Key words: Cultural orientation, seasonal activities, teacher education, bowhead whale course, local knowledge, subsistence whaling, teaching styles

The mission statement of Ilisagvik College includes a goal of incorporating Iñupiat culture, values, and knowledge into its curriculum. This usually comes as a surprise to new faculty, who arrive without knowing this ahead of time and who don't have much of a clue as to how this can be accomplished. The college has responded by including a session on cultural orientation during its fall faculty orientation. We try to instill in faculty, especially the new arrivals, that teaching Iñupiat students on the North Slope involves a lot more than just altering course content to include familiar materials found in the Arctic. Our cultural orientation includes information about the seasonal activities in the Iñupiat community, basics of the language and common expressions, teaching and learning styles, and an overview of Iñupiat history during the twentieth century. All of this material is also now published in our Academic Procedures and Faculty Handbook, and distributed to every faculty member.

In addition, the college holds monthly Cultural Orientation Programs for college staff and the general public. These presentations usually reflect seasonal activities. At Christmas time, the topic is Eskimo games, which take place in that season. In spring, the topic is whaling, which is the main activity of late spring and early summer. Ilisagvik College has even packaged these Cultural Orientation Programs for presentation to groups in other regions of Alaska. Teams from Iñupiat History Language and Culture Commission (IHLC) and the college travel to Anchorage or other cities from time to time to conduct workshops.

There is an Iñupiat Studies Department within the Academic Division of Ilisagvik College that offers courses in the Iñupiat language, Skin Sewing, and Eskimo Dance. The Iñupiat Studies department not

only offers its own degrees and certificates in Iñupiat Language Teaching, but also is now very involved in the NSITE (North Slope Iñupiat Teachers Education) Program, which is offered by our college Education Department.

It has been my task to incorporate Iñupiat knowledge into the college science program. Fortunately this task has been made easier by the long and mutually beneficial relationship between NARL and the Iñupiat community of Barrow. Fifty years of NARL presence has provided a firm science foundation on which to build. Barrow residents have worked alongside visiting scientists (Fig. 1) and learned the value of scientific activity, while at the same time understanding that only with their help and knowledge could scientists survive in the arctic.

One especially noticeable interface between Western science and traditional local knowledge occurs every time subsistence hunters harvest a bowhead whale and haul it up on the beach or onto the ice. While the whaling crew proceeds to cut up the whale and distribute shares in time-honored ways, scientists from the North Slope Wildlife Management Department take measurements, check its condition, and perhaps sample vital organs for various research projects. It is a cooperative effort, done with the permission and friendly indulgence of the whalers. Having observed this, it seemed natural to build a course around this important animal. With the gracious help of Dr. Tom Albert, Ilisagvik College offered "Alaska Mammals—The Bowhead Whale" for the first time in the spring of 1997.

THE BOWHEAD WHALE COURSE

This course is an elective, one-credit course, which meets once a week for ten weeks. It is designed to blend Western scientific knowledge about the whale and

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Fig. 1. Visiting owl biologist, Denver Holt (left) discusses with Ilisagvik College student, Christopher Savok, the differences between small mammal skulls commonly found in pellets regurgitated by several species of predatory birds near Barrow, 1992. Photo, D. W. Norton.

traditional Iñupiat knowledge accumulated over generations by subsistence whalers. Topics covered in the course include:

1. Taxonomy of whales
2. General distribution of the Bowhead whale stocks
3. Bowhead migration and feeding habits
4. Adaptation of the Bowhead to its environment—deep diving and keeping warm
5. Subsistence hunting—how it is done; sharing of the whale in the community
6. Regulation of the subsistence hunt
7. History and politics of the International Whaling Commission (IWC)
8. Conservation
9. Industrial impacts on whaling in the 1990s—the oil industry
10. The future for both animal and hunter—pollutants in the arctic

We are fortunate in being able to draw on local expertise when offering this course. Not only do we

have Dr. Albert, with his twenty years of whale research experience as the lead instructor, but we also have a local whaling captain, Harry Brower, Jr. (Fig. 2), who enjoys teaching students about hunting and distributing the whale. On occasion we have been able to recruit Jacob Adams, CEO of Arctic Slope Regional Corporation, to meet with the class. Jake was instrumental in the 1970s in convincing the IWC of the value of traditional Iñupiat knowledge in estimating the Bowhead whale population size by strongly suggesting that many whales were not being counted simply because they were swimming out of sight under the ice (Albert; Dronenburg, this volume). Jake's protestations in Washington, D.C. are largely responsible for the subsistence hunt that Iñupiat enjoy today.

It has been a wonderful experience to have those who actually depend on the whale for a portion of their food to be involved in the class, and to present the native perspective first-hand. These classes have been our most popular.

OTHER COURSES

The success of the Bowhead whale class has led to the idea of guidelines, which can be used in evaluating the suitability of a subject (animal or plant) for teaching Western science in an Iñupiat community. The higher



Fig. 2. Student-turned-teacher: Harry Brower, Jr., demonstrating techniques for skinning arctic foxes in an Ilisagvik College laboratory class on scientific taxidermy, 1992. Photo, D. W. Norton.

one can score an organism, the more successfully it is likely to be received in the classroom:

1. Does the organism live year round in the Arctic?
2. Is the organism one that is familiar, that is, do students notice it often?
3. Is there a body of accessible scientific knowledge about the organism?
4. Is there active research on the organism?
5. Is the organism culturally significant (food, crafts, clothing)?
6. Does the organism have economic significance?
7. Can students find and collect the organism? (Fig. 3)

While most of this is just common sense, it does at least provide a uniform set of guidelines, and can be especially helpful to the new science teacher in the Arctic, whose education is just beginning. That person may not know that learning about countercurrent circulation in animals can be illustrated better in Anaktuvak Pass with the caribou than the whale. Hull and Souders (1996) urge community college faculty to recognize that students learn best in the context of their real world, and that the most successful instruction will



Fig. 3. Ilisagvik College students, Doreen Lampe and Jenny Brower, adding freshly collected live marine invertebrates to a cold-water aquarium in Building # 360, 1993. Photo, D. W. Norton.

be “contextual based”. That is exactly what we are all about at Ilisagvik College.

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Thoughts on the Future of UIC-NARL

Glenn W. Sheehan¹

UIC-NARL has come a long way since the Navy advertised for a contractor to demolish the installation. Scientific activity in the Barrow region is increasing. The UIC-NARL infrastructure now draws some support from the National Science Foundation's Office of Polar Programs through a Cooperative Agreement with the Barrow Arctic Science Consortium (BASC), the same agreement that has funded production of this book.

Starting with the National Science Board's 1987 report *The Role of the National Science Foundation in Polar Regions*, a report spearheaded by Dr. Rita Colwell, current Director of the National Science Foundation (NSF), there has been increasing attention focused upon providing a stable and up to date platform in the American Arctic upon which good research can be based. Specific recommendations for supporting science activities were made in the 1997 Arctic Logistics Report (*Logistics Recommendations for an Improved U.S. Arctic Research Capability*, United States Arctic Research Commission). NSF's sponsorship of the Barrow Area Research Support Workshop (*The Future of an Arctic Resource*, Arctic Research Consortium of the United States 1999) has led to the scientific community's infrastructure support plan that is currently being implemented through the NSF/BASC Cooperative Agreement.

The NARL 50th Anniversary Celebration in 1997 was seen as a test of concept for a regionally based science support establishment on Alaska's North Slope, that is,

a test of BASC. The Celebration's week of activities, organized by BASC, received good reviews by everyone involved. The NSF/BASC Cooperative Agreement became effective less than a month after the conclusion of the Anniversary activities.

Today, BASC provides logistic support directly to NSF researchers in the Barrow/Atkasuk region. BASC conducts a vigorous outreach program, connecting North Slope school students and residents with scientific projects, and connecting scientists with the community. We advocate for and facilitate inclusion of Iñupiat Eskimo residents in scientific endeavors, and helped place the only North Slope resident to work on NSF's SHEBA project.

As in real estate, location is everything. The local connections that BASC facilitates between community members and scientists, and between scientists and students are valuable to both sides. Interestingly enough, the cross-connections BASC helps foster between researchers also pay off scientifically with better or collaborative data sharing and, sometimes, by useful modifications to research designs.

Early in the new century we expect to see the first new research building construction at UIC-NARL since the 1960s. We expect that Barrow, often called America's Science City, will continue to grow as a research destination of choice by US and international researchers.

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Future Directions for Arctic Research

George B. Newton¹

The future for arctic research could not be brighter. In the decade of the 90s we have learned many new and important things about the Arctic: its environment is important, not just to those who live and work there, but to the rest of the world; it is the weather engine to the Northern Hemisphere and indeed the Arctic Ocean is the driving force for the world's oceans; its resources are plentiful and becoming more accessible for recovery; other things are changing, some for the better, some for the worse (like fish stocks and marine mammal populations), and some whose impact will not be determined for many years (like average temperature changes and glacial retreat). All of this naturally leads to a need for more knowledge, which dictates more research. Clearly, the need for arctic research is great ... and it is perhaps increasing. This is because so many of the world's and our nation's environmental concerns are being identified as originating in, being magnified by, or being strongly affected by the unique arctic environment—on land, in the sea, and in the atmosphere. As I have discovered in my tenure with the U.S. Arctic Research Commission, there is no lack of interest on the part of the people of the North Slope to discuss individual and collective concerns about what is impeding our ability to understand the Arctic well as it should be understood. But on the broader national front we who have arctic research interests are really a very small part of the pie.

Specifically: The United States spent \$71.23 billion on all forms of (government sponsored) research in FY96. Of that, only \$172 million was directed toward arctic research. Kind of describes the problem in one gulp doesn't it? Only 0.024 percent of our total national commitment goes to arctic research!

A logical question is: Why is it that way if the Arctic is so important? I theorize that the answer rests in both the practicalities of conducting research, and, perhaps to a lesser extent, the psychology of planning and

selecting research. Isn't it easier to be interested in tropical fish than in the Arctic charr? Isn't it easier to collect data in all seasons, particularly if you can inexpensively reach your destination and work in an uninterrupted fashion? Why work in gale-force winds at 40° below zero after being delayed getting to your research site by several days due to the combined challenges of weather and complicated logistics? Isn't it easier to be able to predict accurately how things will work in the field, as opposed to living and planning by the axiom that "nothing ever works the same in the Arctic?"

The answer is 'YES' in each case. So that's why we're a smaller group and receive less attention, appreciation, or support ... and regrettably it is the perspective from which we must view the future. All of us must continue to discuss the need for more research in the Arctic. Congress must know. Program managers must know.

Let me at this point suggest we adjust our Arctic institutional thinking, in order to accomplish the research tasks we all believe are of critical importance to improved understanding of the Arctic. I offer three concepts that we must practice in planning and executing our research efforts, specifically the ones we want most to accomplish. They are:

1. Focus research efforts.

We can no longer "do it all." Research must be meaningful and work-toward solving a genuine and relevant problem or fulfilling a similar information void.

2. Communicate research objectives.

Go both to seniors and subordinates, and gain their support. Urge them to become proactive by convincing them of the project's importance.

3. Cooperate in our pursuit of knowledge.

Devise possible ways to share resources,

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logistics and data with others that share your broad interests.

In addressing the first two concepts, we must first recognize that in the current fiscal environment (and for the long-term future) our nation, and indeed the world, cannot support investigation into every documented and unfilled research requirement in the Arctic. We must focus our research interests and resources on the higher priority set of important problems. The federal government simply cannot fund science that is not relevant. No organization which funds research can support every need brought to its attention, even though that need may be valid in some respect. It must be relevant. What the Arctic Research Commission is chartered to do is to recommend research priorities to the President and to Congress. Therefore we must put each project or idea in its proper place in the research queue. The first defining question we ask ourselves is about relevancy.

What will help a research need, however, is to have it be made part of a focused research effort. I believe that it would be valuable if the Arctic science organizations and advocacy groups developed consensus priorities for Arctic research. The more people who agree, the stronger the case. It's another form of relevancy and justification. Pass these priorities around. In our bureaucracy putting things in writing helps. BASC and the Alaska Native Science Commission (ANSC) could originate things like that. We at the Arctic Research Commission welcome the input, which would be considered, in our biennial Goals and Objectives Report made to the President and Congress. As you know, the Interagency Arctic Research Policy Committee (the IARPC) does maintain a Five Year National Arctic Research Plan, also updating it biannually, in part based on input from the USARC and from the eleven agencies represented on the IARPC. I would like to see independent, non-governmental organizations—such as the American Association for the Advancement of Science, Barrow Arctic Science Consortium, the American Geophysical Union, or the Alaska Native Science Commission—which truly represent science and research interests, make prioritized inputs, recommending research objectives at the very start of the planning process.

It follows that such plans and priorities should be consulted in the funding of science.

Sometimes, however, that kind of a logical path is not possible, because funding projections must go through the Office of Management and Budget (OMB)

and Congress. People are often dismayed when one organization or committee does not share the same imperative as they do.

As much as we have tried, at one time or another we have not always been successful in getting our pet program funded. To have a better chance of doing so, one must communicate, articulating the research objectives and anticipated results both up and down the line - building a consensus.

First you build a plan that meets both a research objective and a national priority (which I will address shortly); next you develop a sound, rational case for the programs within it and you communicate as I suggested earlier ... building support and focus; and lastly, you stick to your objectives. There is no quicker way to kill a promising research effort than by changing your mind!

Perhaps I can summarize the necessary ingredients for the ultimate program generated at the national level.

- The program must fill the needs of both the political and science communities;
- The program must have a group committed to making it happen;
- The program must be in the national interest; (A cost breakpoint exists for all agencies and it varies between them ... but the program does not have to have a cost limit); and
- The Program must connect with priorities, for the current administration those priorities are economic security and job creation.

The last concept of my earlier list was cooperation. In my 5-plus years as a Commissioner, I have come to appreciate this factor very much. The only way we can do more with less is by cooperating in almost every aspect of science—from logistics support to data collection and ultimately, data sharing. It's just got to be the new rule of science, I know this runs counter to many of the experiences we have had in the research world, but we simply must adapt. I won't dwell any longer on this concept other than to say cooperation is at the very foundation of the Arctic Research Commission's objectives and we have reflected it in (1) the near team agreement we are developing with the Canadian government on the sharing of Arctic research logistics resources between our two countries; (2) our leader-

ship in drafting the science plan for the new IARC being built at UAF as a joint effort between the U.S. and Japan; and (3) in the Submarine Arctic Science Project. All these are unique cooperative efforts that have succeeded or will succeed in magnifying both the data and dollars available for researchers.

In closing let me leave you with this thought. Over 85 percent of the people in the world live in the Northern Hemisphere ... on continents bordering the Arctic Ocean. That fact alone makes intense study of

every aspect of the Arctic not just important, but critical. Stated bluntly: we as a nation, now more than ever before, need to do science and research that is relevant where it is relevant, and not just do science that is fun.

Only through focusing our efforts, communicating our programs and their rationale, and cooperating in their planning and execution can we continue to be a world leader in Arctic science.



Building 250—the old main Laboratory—as it appeared in the early 1960s. Photo, J. F. Schindler, courtesy of H. J. Walker.

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The University of Calgary

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Preface

The Arctic Institute of North America (AINA) played a significant role in the early years of research carried out at the Arctic Research Laboratory (ARL) - later named the Naval Arctic Research Laboratory (NARL) and finally the UIC-(Ukpeagvik Iñupiat Corporation)-NARL. The AINA was a young institution itself, having been established in 1945, just two years before the beginning of the ARL in August 1947. The laboratory has continued for the past fifty years through periods of intense use and growth, as well as threats to its very existence. During the 1980s the NARL was transferred to the Barrow community and is managed by the UIC.

Throughout its long history the facility has been host to research scientists and engineers and their families from many disciplines and many nations. In support of investigations conducted there, the laboratory has nurtured a love for the cold regions and has probably been an important factor in shaping future professional careers. A major attribute of the laboratory was its association with the residents of the Barrow community. Sharing of experiences was an important asset and greatly benefited the research effort. The UIC-NARL sustains that tradition.

Representatives of the Arctic Institute of North America felt that one way to commemorate the event of the fiftieth anniversary would be to communicate with former investigators and solicit their remembrances of what brought them to Barrow, their research experience and their interaction with the residents. The result is this collection of letters spanning the 50-year life of the laboratory.

*John J. Kelley
Project Coordinator
August 1997*

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9 July 1997

The Honorable Benjamin Nageak
Mayor, North Slope Borough
Barrow, Alaska 99723

Dear Ben,

Congratulations on the 50th Anniversary of NARL!

I am glad to have this opportunity to write a few personal remembrances. Just like NARL I find it hard to believe that a half century can go so fast.

On 9 May 1950 I made my first visit to the Arctic Research Laboratory (ARL) at Barrow. It was a brief visit and my main memory is the food. I was with the USGS Navy Oil Unit as a geologic field assistant to Irving Tailleux and B. H. (Bud) Kent. The "Line Haul," a C-46 chartered from Alaska Airlines in Fairbanks, stopped at Barrow on the way to Umiat. Umiat was our base from which we set out with three weasels and six men to do reconnaissance geological mapping of the northern foothills of the Brooks Range, from Smith Mountain Lakes, between the Innavik and Etivluk Rivers, to the aircraft landing area where Driftwood Creek joins the Utukok River. This was one of my best and most enjoyable field seasons. I learned a lot from Tailleux, Kent, and other geologists of the USGS, including visiting experts like Ralph Imlay. The USGS Navy Oil Unit, headed by George Gryc, was an excellent bunch. It produced invaluable information on the geologic history, stratigraphy, and structure of Alaska's Arctic Slope. All of this information was, of course, in the public domain and laid the groundwork for later successes of the oil industry.

I left Alaska in mid-September 1950 and returned in 1960, on the faculty of the Geophysical Institute of the University of Alaska, to use ARL as a base for studies on seasonal snow of the Arctic Slope. Much of the intervening 10 years was spent in Greenland with the Snow, Ice & Permafrost Research Establishment (SIPRE) (now Cold Regions Research and Engineering Laboratory CRREL), with A. L. Washburn as Director. Another important part of the time was spent at Caltech where I had the good fortune of finishing my graduate work under the direction of Dr. Robert P. Sharp, one of the world leaders in glaciology. Washburn had been Director of the Arctic Institute of North America (AINA) when I first visited ARL. In 1948 I corresponded with him about how to get into Arctic research, and have enjoyed his friendship for nearly 5 decades. It was only recently that I learned that he and others in AINA had encouraged the, then new, Office of Naval Research (ONR) to initiate a research lab at Barrow. This became ARL, and the rest is history.

The 1940s were a time for initiating arctic research in both Canada and the U.S. as a result of many

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examples of how our ignorance of Arctic conditions hurt these countries during World War II. During the war several scientists from both countries planned to initiate an organization dedicated to arctic research. As a result of this the AINA was founded jointly in U.S. and Canada in 1945 and dedicated to advancement of knowledge about the arctic by means of research and publication. Within the U.S. Government, the U.S. Army Corps of Engineers established the Frost Effects Laboratory (FEL) in Boston in 1944 and the Permafrost Division of the St. Paul, Minnesota District in 1946. The ONR was established in 1946, ARL in 1947, and SIPRE in 1949. To bring this chilly review to closure, in 1953 the Frost Effects Lab and the Permafrost Division were merged into the Arctic Construction and Frost Effects laboratory (ACFEL) and in 1961 SIPRE and ACEEL merged to become the present CRREL. All of these organizations have been involved with the history of NARL. In particular, AINA served as a granting agency for ONR to fund academic research in the arctic for nearly 10 years before the National Science Foundation (NSF) was established. and much of this was done through NARL.

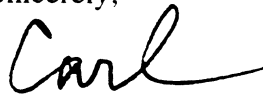
My memories of life at the “Lab” (first ARL, then NARL) with Max “King of the Arctic” Brewer as Director, are mostly fond. Perhaps this is partly due to the filter of time. But it was a great place to eat, sleep and meet with other arctic investigators. The mess hall was often like a seminar room, and the NARL air force was unique.

Much of what I did was away from the lab at sites selected to study the seasonal snow, its quantity structure, and the physical processes operating within it, as well as determining the primary directions and flux of drifting snow. I spent a lot of time in the air, and making ski landings and takeoffs with the late chief pilot Bobby Fisher. Indeed Fisher was instrumental in locating several of the important “drift traps” such as the ones at Atqasuk, which have been studied since 1961, to yield the best information available on the flux of wind blown snow on Alaska’s Arctic Slope.

I also had excellent opportunities to meet people of Barrow in my work at the Lab. I always enjoyed the company of Pete Sovalik and Kenny Toovak among others. One of my finest experiences was when we were doing research in the Lake Noluck region and shared the Lake Noluck hut as it was being built by Harry Brower and Adam Leavitt. For me this highlight has remained a source of pleasant memories.

I look forward to the new NARL operated by Ukpeagvik Iñupiat Corporation (UIC) as a base for continued research in the Arctic. The Barrow Environmental Observatory (BEO) is an impressive step, taken locally. But NARL’s real challenge will be to take full advantage of the rapidly changing developments in transportation and communication. Its location at the edge of the Arctic Ocean and its impressive local talent opens the way for it to assume a broad leadership role in Arctic Research. It may become a critical part of the International Arctic Research Center at the University of Alaska Fairbanks. It could possibly become an international communication center for research in the Arctic Ocean, as well as in Alaska, Canada, Greenland, Scandinavia and Russia. Indeed, NARL has great potential and may become a key player in the circum arctic in ways that we cannot begin to foresee.

Sincerely,



Carl S. Benson
Chairman, Board of Governors

NORTH SLOPE BOROUGH

Department of Wildlife Management

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Charles D. N. Brower, Director



July 31, 1997

Dr. John Kelley
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks, AK 99775

Dear John,

This is in response to your request for a few comments about my experiences while working at the former Naval Arctic Research Laboratory (NARL) in Barrow, Alaska. These comments are included below under two headings.

Working at NARL: July 1977-June 1979:

My first real exposure to NARL grew out of conversations with my thesis director (Rev. Dr. J. A. Panuska, S.J.) in the Department of Biology at Georgetown University. Only a few years earlier I had completed graduate studies at Georgetown University and had returned to my position in the Department of Veterinary Science at the University of Maryland in nearby College Park. One day in 1975 while visiting with Father Panuska he mentioned that a friend of his at the Office of Naval Research (ONR), Dr. Art Callahan, was interested in locating a young scientist who might be interested in spending a year in Barrow at the NARL Animal Research Facility (ARF). As someone who had always been interested in Alaska and the "far north", I told Father Panuska that I'd be interested in learning more about this, so he then arranged a meeting for me with Dr. Callahan. A few days later I was sitting in Dr. Callahan's office at the ONR offices on the outskirts of Washington, D.C. I soon learned that Dr. Art Callahan was the head of ONR's Biophysics Program and was the major supporter of the NARL ARF. As he told me about NARL and the exciting research opportunities there, I could hardly believe what was happening. He could easily see that I was very interested in NARL and when he asked if I'd like to go

there for a visit, I nearly fell off my chair. This seemed like a dream come true. A few weeks later I was in Barrow and was able to examine first hand the facility at which I might be able to conduct research. Seeing the Animal Research Facility (ARF) and its animals made all sorts of exciting experiments come to mind. Soon after returning to the University of Maryland my family agreed that going to NARL sounded exciting and I then prepared a research proposal for Dr. Callahan's consideration. Fortunately the proposal was funded and my Departmental Chairman at the University of Maryland (Dr. Robert C. Hammond) supported my request for a sabbatical leave.

In early July 1977, my wife Marnie, myself and our two children, Tommy (age 12) and Helen (age 9) arrived at NARL. We moved into quonset hut "163 Lagoon" and my work as a Visiting Scientist at the ARF began. Our stay at NARL was to extend for two years (July 1, 1977-June 30, 1979). My research concerned the study of hibernation and the extent to which hibernators can restrict peripheral blood flow while awake during cold exposure. The ARF had an impressive collection of arctic mammals ("Irish" the polar bear, wolves, foxes, wolverines, lemmings, weasels, and a snowy owl). In order to gather a group of hibernators I brought about 15 groundhogs (Marmota monax) from the University of Maryland, and sought the help of Native hunters in obtaining arctic ground squirrels (Spermophilus parryi) and arctic marmots (Marmota broweri). Eventually a group of hibernators was collected including about 20 arctic marmots most of which were captured by Dr. Mike Philo and myself during visits to Meat Mountain in the western portion of the Brooks Range. These and the other research animals at the ARF were well cared for due largely to the efforts of the ARF staff which over these two years included: Dr. Mike Philo, George Selby, Craig George, Sally Manning, Barbara Jackson, Steve Oomittuk, Debbie Fitzpatrick, John Smithheisler, Selena Brotherton, Connie Carter, Dan Coffee, and Tim White.

Of the animals that I worked with at NARL at least two deserve special mention. One was an old groundhog ("Super Kid") that was brought from the University of Maryland and the other was an arctic marmot ("Dugga") that was captured by Eskimo hunters near the village of Anaktuvuk Pass. Super Kid, the groundhog, was more or less a pet and was "retired" from participation in studies. He was "super" due to the great amount of data he provided while we were both at Georgetown University. Super Kid died of "old age" while at NARL and was buried just behind Irish's cage at the ARF. Dugga the arctic marmot arrived at NARL from Anaktuvuk Pass with an injured leg. He was quite young and after much treatment (with assistance from my wife Marnie) the leg healed. While recovering, Dugga stayed in my office/lab at the ARF and soon became quite tame, even crawling up to rest on my thigh while working at my desk. One of his interesting habits was sitting on a tabletop and looking out the window. Some of these "look out the window" sessions were abruptly ended when the shadow of a passing seagull would flash by. When this happened the little marmot would emit a characteristic and very loud alarm call and he would dash down from the table and scramble into his cage on the floor. I suppose that such marmots have an instinctive fear of shadows of large birds since they are preyed upon by golden eagles.

While studying the marmots I had the opportunity to work with Harry Brower, Sr., who worked in the nearby NARL carpentry shop. Mr. Brower constructed from wood the rather complex artificial dens that I used for some of the marmots that were kept outside. With the aide of thermocouples inside the nest boxes, and implanted temperature sensitive telemetry devices (Telonics) in the marmots, we were able to study group hibernation in this interesting animal. Regarding the behavior of these marmots, I am deeply indebted to Dr. Robert L. Rausch who had earlier studied this animal in the field in Anaktuvuk Pass and under captive conditions at the University of Alaska in Fairbanks.

While Harry Brower, Sr. was helping me with the artificial marmot dens I became well acquainted with him and he began to teach me about marmots and other arctic mammals. During our many conversations it soon became obvious that Mr. Brower was not only a highly skilled carpenter and hunter, but he was also an excellent naturalist. His patient working with me helped me gain a better understanding of the biology of several animals (bowhead whale in particular) and an appreciation as to the importance of wildlife and hunting to the Eskimo people. While sitting and listening to Mr. Brower I couldn't help but think that he was one of the best teachers that I've ever had (unfortunately Harry passed away in 1992).

As you (Dr. Kelley) remember, it was during 1978 that representatives from the Anchorage Office of the Bureau of Land Management (BLM) contacted you about becoming involved in the study of the bowhead whale. In those days BLM was responsible for oil and gas leasing in federal waters and there was a "push" to learn more about the Beaufort Sea through the Outer Continental Shelf Environmental Assessment Program (OCSEAP). As you recall, you organized various interested people at the NARL into a group that conducted whale studies for BLM. You called it "Project Whales" and NARL participants included yourself, Dr. Gary Laursen, Ray Dronenburg, Dr. Mike Philo, myself and others.

During 1978 and 1979 Project Whales grew and grew and my participation in the project led me into greater involvement with issues that surround the bowhead whale. During my early involvement in this project I utilized a NARL aircraft (Cessna 185) to visit Point Hope to seek the cooperation of whale hunters there in the sampling of harvested whales. While returning to Barrow our plane ran out of fuel about two miles short of the Barrow runway. The pilot (John Krouse) was able to send a "Mayday" and turn the plane so that we glided back to land on a fairly smooth area of ice on the far side of the lead. While gliding over the open water and toward the smooth area of ice it was an interesting (and scary) experience as the open water rushed by and the seemingly distant ice pan came closer and closer. Fortunately we made it to the ice with about 20 feet to spare. It was really cold standing on the ice, in the waning daylight, hoping that someone heard the "Mayday". Fortunately the message reached NARL and you sent the Twin Otter to search for us. As you may remember there was some confusion during the search as to whether our plane was off the tundra end or the ocean end of the

Barrow runway and apparently most felt that our plane “crash landed” off the tundra end of the runway. The Twin Otter crew (I believe Larry Walls was the pilot) extended the search near day’s end over the water and ice beyond the ocean end of the runway. Needless to say it was a welcome relief to see the lights of the approaching NARL Twin Otter as we stood there on the ice. An image in my mind that will never go away was the sight of “Frenchie” (Alain Le Cloirec, I hope spelling is correct) in the plane’s open doorway as he threw out 4 or 5 five-gallon cans of fuel for the 185. All but one of the fuel cans burst when hitting the ice, but the one that landed OK was enough to save the day. Fortunately the plane started and soon we were rushing along the ice pan with John and I looking out the side windows (the front window was iced over) so as to avoid the jagged ice chunks that dotted the ice “runway”. When safely back at NARL we realized how lucky we were and were thankful for the search effort that involved many people.

While there are other scary stories (such as encountering a young polar bear at the ARF one night while doing telemetry studies with the marmots) there are other interesting points that I’d like to mention. During a visit to NARL before my family came here I had contacted the North Slope Borough School District about the possibility of my wife Marnie getting a teaching position. Mr. Don Renfroe (school district Superintendent) was very helpful and soon Marnie was employed as the Physical Education teacher at Barrow’s Ipalook Elementary School. Our children (Tommy and Helen) attended school for the two years we were in Barrow and made many lasting friends. Some of our more memorable experiences involved the fun associated with eating at the NARL mess hall. We, like other NARL people, enjoyed the food and visiting with friends while eating. None can forget the seemingly “larger than life” presence of Tiny the cook. Although many jokes were made about the amount of grease in Tiny’s cooking, we all seemed to enjoy it. Few, if any, people ever lost weight eating in the NARL mess hall. Over the years I often suspected that more calories have gone through the NARL mess hall line than through the first few years of the Trans Alaska Pipeline (TAPS).

All of the children at NARL really enjoyed the antics of Lane Franich during some NARL dinners. Lane was famous among the children (and many of the rest of us also) for his ability to fall down while walking or down stairs and come up unharmed. When Lane walked through the mess hall the kids always had an eye on him hoping that he would tumble unexpectedly onto the floor and then jump up unharmed. One of his most famous “crashes” happened at the Wien air terminal in Barrow, where he rolled down all of the 15-20 stairs between the first and second floors. Not only did he amaze all of us, but he didn’t get a scratch. His funny antics are remembered by all who knew him. Unfortunately Lane passed away in 1997.

Another interesting sidelight to life at NARL (especially during the winter) was seeing a movie at the NARL theater. While it was often cold in there, and the film broke sometimes, or the order of the reels was mixed up, it was an important thing to see a movie once in while. The movies were especially important in those days since there was no television and our homes had no outside line phones. Our children (now grown

up, Tommy in Michigan and Helen in Arizona) had an experience that few of their “lower 48” friends have had, not only a chance to live in the Arctic but also the chance to be free of television for two full years.

Another interesting time for us was when Marnie made the best guess as to when the resupply barge would drop anchor at NARL during August of 1978. The betting pool provided a prize of about \$275. One of the more unfortunate events we witnessed was the fire at building 250 (the original NARL laboratory building) during the winter of 1978-1979 (I think these dates are correct). Fighting the fire during such cold conditions was very difficult but the fire fighters, under the direction of Tom Opie, saved about one half of the building and kept the fire from spreading to the utilidor and the ARF.

We greatly enjoyed our two years at NARL and found hut 163 Lagoon to be quite comfortable even though it was small and the roof leaked each year during breakup. The little house was really appreciated when the winter blizzards blew and blew during the long and cold arctic night.

In early July 1979 our family left Barrow to return to our home in Laurel, Maryland. I returned to my work in the Department of Veterinary Science at the University of Maryland, however my studies of the bowhead whale continued.

A few comments about experiences at NARL after its closure.

My BLM supported work with the bowhead whale continued into 1980 and the NARL ARF was used as the logistical base in our efforts to collect tissue samples from the Eskimo harvested whales. I greatly appreciate the help received at the time from Dr. Mike Philo, Craig George, Harry Brower, Sr., Dr. Les Dalton and William Kaleak. Obtaining approval from NARL authorities during NARL's “last days” was difficult, but I am thankful for the support we received. I think that our whale project was the last science project going at NARL the day they “nailed the door shut.”

In late 1980 I began to get involved with the North Slope Borough and the Alaska Eskimo Whaling Commission (AEWC) through the efforts of Ray Dronenburg. Mr. Dronenburg was in Barrow working for the Borough's Department of Conservation and Environmental Protection. Through Ray's efforts I became more and more involved in bowhead whale issues and in July of 1981 my family and I moved back to Barrow. I was again on leave from my regular duties at the University of Maryland through a contract between the Borough and the university. Involvement increased in bowhead issues such as the setting of harvest quotas by the International Whaling Commission (IWC) and impacts to the whales and the hunters from offshore industrial activity. In December of 1982 I resigned from the University of Maryland and began full time work in the Borough's Department of Conservation and Environmental Protection (this later became the Borough's Department of Wildlife Management). Marnie and I have been here in Barrow for 18 years and both of our children graduated from Barrow High School. Marnie recently retired after 18

years as the Physical Education teacher for Ipalook Elementary School. During her years as a teacher she has become beloved by many, many children. During almost any visit she makes to our big food store (Stuaqpak), kids come running to her saying “Mrs. Albert, Mrs. Albert how are you, do you remember me?” She remembers all of the children. During her years of teaching Marnie was selected twice by eighth grade students at Ipalook Elementary School to make the Teacher Presentation during their graduation ceremony. Our children (Tommy and Helen) enjoyed their years in Barrow and have many friends. Some of their more adventurous times centered around riding three-wheelers, hunting with friends, and school sport trips to Anchorage and other places in Alaska.

During the years since returning here in July 1981, I have seen the successful transfer of the NARL from ONR to the local people (Ukpeagvik Iñupiat Corporation, often known as UIC). This transfer to the private sector was spearheaded by Arnold Brower, Sr. when he worked for UIC. Although there were many delays, the transfer was completed and now the old NARL has become the UIC-NARL Facility. One of the first “rent payers” into the UIC-NARL Facility was our department (Wildlife Management) when we moved our offices here in 1985. Our department occupies most of the “ocean wing” that extends away from the old library area of the main building. The library area is now a dining hall, as the library contents were taken to the University of Alaska when NARL closed, and the old NARL mess hall has been torn down. When the NARL mess hall was demolished (1986 I think) our family was among the dozen or so people to partake of the last meal there. Before the bulldozers did their final work, the mess hall sign was “rescued” and now is on display inside the ARF as a reminder of days gone by.

As soon as our department (Wildlife Management) moved to the UIC-NARL Facility we also rented the ARF. We have used the ARF as a logistics base to support our now very large bowhead whale research effort. The ARF has also been used to house a “parade” of young (and some old) scientists who wanted to return to Barrow or to come here for the first time. All of the mayors of the Borough for whom I have worked (Jake Adams, Eugene Brower, George Ahmaogak, Jeslie Kaleak, Ben Nageak) have been very supportive of science. All of these Mayors have supported our work out of the ARF and have approved use of the ARF (no charge for lodging) by a wide array of visiting scientists. Now that the UIC-NARL Facility has become better developed it is also providing space for visiting scientists and is encouraging the return of large scale research projects to the now “more modern NARL”.

When our department began utilizing the ARF it no longer had any animals so that it could not properly be called the Animal Research Facility. Since we were all so used to the abbreviation ARF it was decided to call it our Arctic Research Facility therefore the beloved ARF could live on as it does to this day in the support of arctic science.

Well John, that’s about all I can put down in a brief remembrance of times at NARL. All of us who had the good fortune to be at NARL during its ONR days have many good memories (and maybe a few scary ones). I want to thank you for the help you gave to young

scientists like me when my family and I arrived in July 1977. Your tenure as the last NARL Director is something of which you can be proud. We all know that you fought long and hard to save the NARL but the “economies” as seen by ONR at that time were against NARL. Not only did you work hard to save NARL, but your involvement with members of the Eskimo community helped assure a community interest in the facility when it was declared “surplus.” That strong community interest in NARL, developed over many years, was critical in the vigorous efforts by UIC to obtain the NARL and to use their own resources to modernize the facility. The old NARL is gone but it lives on in all of our memories and in the modernized UIC-NARL Facility that continues to support science and education in the Alaskan Arctic.

I hope these few pages are helpful.

Sincerely,



Thomas F. Albert, V.M.D., Ph.D.
Senior Scientist



Colville River and the Umat airstrip from the air, as they appeared in 1961. Photo, J. J. Koranda.



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May 9, 1997

The Honorable Benjamin Nageak
Mayor
North Slope Borough
Barrow, AK 99723

Dear Mayor Nageak:

Congratulations on the 50th Anniversary of NARL! It is not possible to consider the history of western arctic research without noting the role of the former Arctic Research Laboratory, later the Naval Arctic Research Laboratory and now the UIC-NARL. My experience with the Naval Arctic Research Laboratory began many, many years ago. I suppose it was in 1956 or so, when a University of Pittsburgh graduate student working with my then husband did his thesis research there. I pored over color slides of snowy owls, jaegers, arid bleak-looking landscapes, and thought I might like to try working there some time, myself. More than ten years later, as a relatively greenhorn faculty member at the University of Alaska, I was fortunate in receiving support to work on ice algae in the nearshore area of the Chukchi Sea with Dr. Rita Horner. At that time, Rita was one of the few women scientists who had had the chance to work there. We made sure we had cold water divers by arranging to have our own trained (one of them was Bob Clasby, now Director of Commercial Fisheries for the Alaska Department of Fish and Game), and then proceeded to do some measurements of ice algal photosynthesis from below the ice, a first at that time. It took a big hole in the ice, a warm up hut, a competent truck driver on the ice, and our human ice seals. In this way, we were able to make measurements without losing algae from the bottom of the ice and under natural light conditions. While working there, I also managed to sample some of the freshwater environments, including Ikroavik Lake. I got used to weasels as a form of transportation, and was awed by the ability of the local Eskimo experts to distinguish between safe ice and dangerous ice, when both were covered with water of undetermined depth.

Then came the National Science Foundation International Biological Tundra Biome program, and I was very lucky to get involved in both the aquatic work and the terrestrial work. Focusing on a series of tundra ponds, we were able to repeat and expand upon the earlier work of Dr. Jaap Kalff. My group was responsible for nutrients, phytoplankton, primary productivity, chlorophyll, and nitrogen cycling. On the terrestrial side, we investigated nitrogen fixation. The latter was especially interesting and we developed close collaboration on a circumpolar basis with other national tundra biome programs. Some of those collaborations and contacts continue even now,

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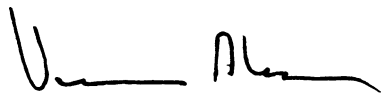
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especially the Finnish contact with the late Paavo Kallio and Sinikka Kallio. We also played a role in the Colville River project, which looked at the entire length of the river and the nearshore estuarine area. This was funded by the Environmental Protection Agency the Alaska Sea Grant College Program, and Atlantic Richfield Company. As part of this, one of the IBP international collaborators, Stefan Holmgren from Sweden, flew a transect along the river to study the phytoplankton populations with latitude in the adjacent freshwater ponds and lakes. Later, we conducted research on Peters and Schrader Lakes from Barrow. as well as an extensive survey of lakes using remote sensing for Jack Mellor's Ph.D. thesis.

There are many memories. The flight on an air cushioned vehicle to Ikroavik Lake, aborted en route when the aircraft crashed into a seismic ditch as it lost its air cushion as it passed over it. Even more striking was the satisfaction on Kenneth Toovak's face when he walked back some five miles to NARL to fetch a weasel to pull the aircraft out of the ditch. The weasel won again! The flight on the R4D to see the total eclipse of the sun at Umiat! The beauty of the tundra flowers! NARL played an important and critical role in Alaskan arctic research and its legacy will form an excellent basis for future research in northern Alaska.

Without the Laboratory, programs such as AIDJEX would have been impossible, and the work on ice islands would not have happened. The NARL has been the most important element in arctic research not only in the United States, but globally as well.

Yours sincerely,



Vera Alexander
Professor
Dean

VA/rm

1997.5.29

Dear Kelley sensei

Congratulation on 50th anniversary of NARL!

I am sorry that I was so late for sending a letter, I stayed Sakhalin for a month. Today I wrote a anecdotal stories of the late professor in Barrow. Please correct my poor English.

A anecdote of the late professor Tabata in NARL

We Japanese sea-ice group visited NARL in 1970. The leader of our group was the late Dr. Tabata who studied the mechanical properties of sea ice in the Okhotsk sea coast of Hokkaido and around Barrow hard. He was a man of very cheerful fellow and he believed that "Good beer makes good study."

At that time the scientific director of NARL was our friend Dr. John Kelley. We visited his office in NARL to pay courtesy call on him and his staffs who helped us very kindly every time.

Toward the end of meeting, Dr. Tabata noticed that he had no beer for that night and Barrow was a dry town. He suddenly changed the topic of our conversation and asked John with a worried air whether he had beer or not.

John answered his question gently, "Of course, we have many many polar bear." I didn't know why, Dr. Tabata replied gleefully, "That's wonderful."

After we returned our room, Dr. Tabata ordered me to go to John and get beer. I told him that John didn't say about beer but bear, he changed his countenance and dashed to John.

Good regards to your Elena.

Sincerely yours,

M. Aota

FAX 01582-3-5319

e-mail

aota@pop.lowtem.hokudai.
ac.jp

I first met Dr. Max Brewer on board the U.S.S. *Burton Island* AGB 1 while setting up Ice Station ARLIS I September 10, 1961. I inquired of Dr. Brewer of my chance of employment at the Artic Research Laboratory as I was planning on retiring from the Navy in April 1961 after twenty-one years of service. On the return of the ship to Barrow, John F. Schindler Ass't Director mailed an employment form. I filled out the employment form and mailed it to the Lab and said I would be available on the April 23, 1961. I was employed on that date as Ass't Shop Foreman.

On May 23, 1961 I was aboard the R4D 39078 along with two 180 Cessnas looking for an ice flow on which to set up ARLIS II with Dr. Brewer and Kenny Toovak and four pilots. A large floe was sighted and two 180 Cessnas landed and augered ice thickness for safe landing of R4D. Next day R4D began flying in pre-fab buildings. On completion of construction I was informed by Dr. Brewer I was to be station leader of ARLIS II. I was relieved in November and returned to Barrow and assumed duty as shop foreman.

The shop rendered assistance for scientific projects, building wanigans for field projects, pre-fabs for future ice stations, cages for polar bears, wolves, fox, wolverine etc.

I have a very high respect for the Eskimos who worked for me. They are true craftsmen of their trade. A few - Harry Brower Sr., Joe Ahgeak Sr., Arthur Neakok, Bud Kanayurak, Antonio Weber, Herbert Leavitt, Baxter Adams, Nate Elavgak, Pat Okpeaha, Josh Okpik, Carpenter Shop. Percy Nusunginya, Joe Ahgeak Jr., James Ahgeak, Paul Kignak Jr., Welding Shop. Special thanks to Kenny Toovak, Equipment Foreman, for all his advice and help.

After my Naval career and 14 1/2 years at Naval Artic Research Laboratory, I felt it was time for retirement. I have purchased a five-acre lot on a lake in Washington State.

JOHN BECK
2104 Sunday Lake Rd.
Stanwood WA 98292

Dr. John J. Kelley
C/o Arctic Institute of North America
University of Alaska
Fairbanks. Alaska 99775-6808

Dear John:

This letter is in response to your request to contribute to a commemorative volume of letters from former investigators in celebration of the 50th anniversary of the NARL. My acquaintance with the NARL began in 1959 during the extension of the IGY polar studies. This was the period during which the planning for the sea ice drifting station "Charlie" was in progress.

During the interval from 1959 to 1966 I was in the Arctic Program in the Department of Atmospheric Sciences, the University of Washington, Seattle, under an ONR grant managed by Phil Church, chairman of the department. My research work in the Arctic was exclusively on the properties of sea ice. It was a pleasure to be a guest of the NARL. Our planning and specialized equipment supply was always at and from UW, however, it was never possible to be prepared for all contingencies so we came to rely on the NARL for its excellent support for local transportation, comfortable housing, fine food, laboratories, cold rooms and much equipment. Generous, willing help for the investigator to accomplish his research was always abundantly available.

The sea ice drifting stations were a significant part of the research and support activity during this period. Drifting station "Charlie" was managed and sustained by the U.S. Air Force and was the first drifting station located off the North Alaska Coast. The search for suitable ice was conducted by Max Brewer and members of the NARL staff. The station equipment was delivered by air-drop by the USAF. It was at this time that I gained a real admiration for the innovative capabilities of the NARL people. A D6 cat was air-dropped for runway and camp preparation; personnel had been previously landed by DC-3. Kenny Tuvak [Toovak] and I were watching as the bull-dozer was clearing snow and ice for the runway. After several passes Kenny said, "that is wasting too much time - when my turn comes I'm not going to stop the cat by going back and forth. I'm going to set it at high speed and keep it moving: I'll circle and pack the snow, then make the cut in one direction." He did, and nearly finished the job on his shift. Succeeding operators followed his method.

This runway was used for the life of the station. I patrolled it constantly during the break-up, and before it was abandoned, to ensure that no fracture would prohibit access and evacuation. Cracks did appear, but on measuring their width and the distance between them, it was easily calculated that they were due to thermal contraction. From this I

guessed that there should be a thermally stable ice pad - it turned out to be an oval shape, probably a little larger than a football field. I was able to verify this many times on flights in the light planes, generally with Lloyd Zimmerman. One such oval pad lodged against shore near the NARL airport where I was able to examine it in detail.

Frankie Akpik was with us on the drifting station ARLIS where he quickly demonstrated his intuitive talents in keeping the diesel generator running smoothly. It was a single cylinder engine and by touching any wall in camp every combustion could be detected. It always seemed equally obvious when it failed to fire - generally in the middle of the night, then wait for the next one, then awaken everyone and warn that power would be off, light a lantern and tell Frankie we had maintenance work to do. I held the lantern while he disassembled the head, cleaned everything and replaced the injector. I have never known anyone to be as careful and methodical - was afraid it would get so cold that we'd have trouble starting it again. Frankie had never worked on that kind of engine before - he examined each part carefully as it was removed, placed it on a tray and proceeded, never making a false or unnecessary move. It was reassembled, all parts in perfect order which was ultimately the perfect way to save time. Frankie would take one fly wheel and with me on the other we would crank it to our maximum speed with no compression - then Frankie would place a few drops of ether in the line and flip the valve to compression - it would shudder and blow smoke but settle down and run smoothly for many weeks before a repeat was necessary.

There were many others with whom I had the pleasure of working and knowing: Eddie Hopson, Chester, and Pete Sovalik and others whose names I have forgotten. Pete was with us on the ARLIS drifting station and we patrolled the ice regularly together. Pete was an inveterate naturalist and from him I gained an excellent background knowledge of Polar bear habits and hunting tactics, seals, arctic fox, walrus and whales and everything that moved.

When not out on a drifting station I worked in the NARL laboratories. It took long hours in the cold rooms to try to understand the mechanics of crystal growth in a differentiating medium. No single property of crystal or medium was adequate to explain the characteristics, and crystal orientation in the end product. The physical- chemical properties of the complete system were involved. In sorting out the interplay of factors Charly Knight was a most effective "devil's advocate."

The people at the NARL, along with other investigators, made it possible to have a much broader acquaintance with the arctic than I would have otherwise experienced. John Kelley invited me to spend a day at his research site located at the very tip of Point Barrow. Bobby Fischer invited me to go with him many times, especially when he was tending a research site for an absent investigator. Ed Donnelly and R. Dickerson generally were involved in a search for a new ice pad. Bob Main invited me to go on an

extraordinary trip over the Brooks Range.

I have only fond memories of the work and the people at the NARL. For someone who had never previously been to the Arctic, and whose only introduction was to have read all of Jack London years before, the experience was an absolute delight. I wish to thank all who contributed towards making it possible and productive.

I would especially like to offer my warmest congratulations to Mr. Benjamin Nageak, UIC, BASC, Ilisagvik College and the North Slope Borough for their persistence In maintaining research and science as a part of the everyday life of their community This kind of perseverance in providing the environment for asking questions and searching for new answers helps to guarantee that they both will live for all of us.



Kenneth O. Bennington
Retired Research Chemist; Geologist
11445 S.W. Lynnvale Drive
Portland, Or 97225



Subterranean iglu, or house, at Birnirk Site, 1952. Photo, J. J. Koranda.

3218 Myddleton
Troy, Michigan 48084
May 14, 1997

Mr. John J. Kelley, Coordinator
Arctic Institute of North America
Rasmuson Library, P.O. Box 756808
Fairbanks, Alaska 99775-6808

Dear Mr. Kelley,

I have been searching long and hard for a valid reason to revisit the North Slope, Point Barrow in particular. It seems the celebration of NARL's 50th anniversary is just the motivation needed. Congratulations are in order to those that have kept the worthwhile scientific endeavor alive for so long. I am sure there have been some trying years in the past, and probably some are yet to come.

My involvement with the Lab began in March of 1951 when I arrived to become Observer in Charge of the Barrow Magnetic Observatory for the U.S. Coast and Geodetic Survey. Though never a member of the official Lab "family", the Lab provided lodging and work apace that were both greatly appreciated. My two year stay ended April of 1953.

The Barrow Magnetic Observatory was established to monitor the earth's magnetic field in the vicinity of Point Barrow. To fully describe the magnetic field both direction and intensity were measured on continuous photographic recordings. Continuous recordings were required to note field changes on both a short and long term basis. The work was routine in nature—compilation of facts on a daily basis, calibration of instruments, and development of the photographic records. The event I remember most occurred during a magnetic disturbance—the records revealed a sixteen degree change in declination (the angle between true North and magnetic North) in about a six minute time frame.

My time at Barrow was made very pleasant by the people with whom I was associated. The Eskimos employed by the Lab were fine

people. Chester Lampe, Pete Sovalik, and Adam Leavitt all gave great insight into Eskimo living and language. The times we visited their homes in the village are still remembered as special times.

The people of the Lab were exceptionally great. I consider myself lucky to have been in the company of and worked with the likes of; Dr. and Mrs. Wiggins, Max Brewer, Frank Talbert, Dr. Max Britton, Ode Odendhal, and numerous others. These were "one of a kind" folks.

Away from the everyday routine, we did have good times. I recall among other things:

Walks out on the ocean ice,

A two weasel trip inland to gather specimens for the Department of Public Health,

A trip to Wainwright,

Playing in the "Blubber Bowl"—basketball versus the Eskimos,

Often paying for an evening's entertainment at the poker table,

Losing at Cribbage and Acey-Deucey,

Tracking a Polar Bear off the point one night,

Crossing an inlet hopping from ice chunk to ice chunk,

Fording a channel in a weasel only to find no drain plugs had been inserted to keep water out,

Getting a Jeep high-centered in deep snow,

Five nights on the trail with Chester Lampe to gather Caribou meat, but after three days of Arctic storm, returning home empty-handed,

Dinners with Chester and his family,

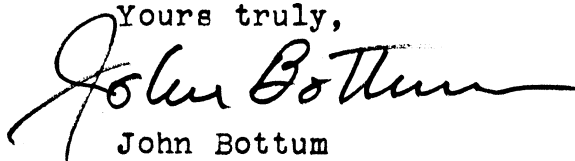
Pilgrimages to the Wiley Post-Will Rogers monument,

Morning and afternoon coffee times, and many others.

I am looking forward to the 3rd to the 8th of August. I will try to forward some pictures in the next few days.

My thanks to those that remembered me!

Yours truly,

A handwritten signature in cursive script that reads "John Bottum". The signature is fluid and elegant, with a long horizontal flourish extending to the right.

John Bottum



Max C. Brewer, Admiral Leydon, John F. Schindler, and Max E. Britton. Photo courtesy of J. F. Schindler

MAXWELL EDWIN BRITTON
2330 NORTH VERMONT STREET
ARLINGTON, VIRGINIA 22207

June 15, 1997

Dr. John J. Kelley
The Arctic Institute of North America
Rasmuson Library-University of Alaska
P.O. Box 756808-Fairbanks, AK

Dear John;

It is very appropriate that the Arctic Institute of North America (AINA) play a significant and visible role in the celebration of the 50th anniversary of the founding of the Naval Arctic Research (NARL). I congratulate you and Carl Benson for your role, not only of organizing a volume of letters for presentation to the Natives of the North Slope Borough, but for the important work you do in maintaining an Arctic Institute presence and influence in the United States. My congratulations are expressed further to the Institute, in its original binational context, for all of its historic achievements in arctic research, especially as those efforts were directed in so many ways to the history of NARL.

The Institute itself was only two years old when in 1947 the first research program the Office of Naval Research (ONR) sent to the Barrow area, within Naval Petroleum Reserve No.4, became the starting point of what was then called the Arctic Research Laboratory (ARL), although it was not designated as such until the following year. Those were exciting years just after World War II in the developing art of federal support of basic research. ONR celebrated its 50th anniversary only in 1996 and the National Science Foundation is still to do so, in the year 2000.

Later I shall make further comments regarding AINA. Turning now to the principal reason for this letter, I extend my sincerest congratulations to Mayor Benjamin Nageak of the North Slope Borough and all of the Iñupiat people for their contributions to NARL research programs. They were essential and highly valued personnel from the beginning to the end of the period of years of U.S. Navy responsibility for the Laboratory. Those Natives directly members of the NARL staff contributed faithfully and generously with their wisdom, their intelligence and their

special knowledge, not only in terms of the scientific and engineering projects, but with respect also to the safety and well-being of all investigators placed in their charge or under their influence.

Surely, the entire Native population of the Borough must share in deserved praise for their support of the very wise move to acquire the Naval Arctic Research Laboratory (NARL) facilities when they became excess to further Navy need and to convert them to beneficial intellectual uses of the Barrow and total Borough communities. I am sure I do not yet know what all of these uses are but, to the extent I do know of some of the educational and research functions, they seem quite consistent with the goals of ONR, therefore of NARL, from the beginning, namely, the acquisition and advancement of knowledge about the Arctic.

Further, I wish to congratulate Mr. Richard Glenn and all members of the Barrow Arctic Science Consortium for the sponsorship of the Conference on “Science in the Community” in celebration of the 50th anniversary of the founding of the NARL. My praise of these efforts must be shared also by those cooperating organizations, Ilisagvik College and the Ukpeagvik Iñupiat Corporation. I appreciate being invited to participate in the celebrations since a large part of my professional life was dedicated to research and administrative roles related to the Laboratory and to friendly relationships with the Community—eighteen years, to be exact.

John, you asked for a statement concerning my involvement with NARL. I shall try to do so but it is not easy to be brief since I enjoyed both research and administrative roles over a rather long period of time. In early June of 1952, at age 40, 15 years into my academic career, Associate Professor of Biological Sciences at Northwestern University in Evanston, Illinois, I arrived at NARL for the first time. I had with me one graduate student, Arthur Schaff, to do a single summer of research on vegetation of the local tundra. The research was conducted with myself as Principal Investigator under a contract between Northwestern University and the ONR as part of the Arctic Program of which Dr. Louis O. Quam was Head.

During the summer Quam visited NARL and convinced me I should continue the program through the winter. I could not personally remain for such an unplanned winter away from my faculty duties nor did I have a graduate student who could do so. After a few weeks of stressful trying to locate help via the mails and intervention of friends, Dr. John L. Mohr of the University of Southern California, with whom I was sharing a laboratory at NARL, turned up a candidate for the position. He was Howard Craig, whom many of you will remember, a zoology graduate student, who arrived at Barrow in early September and spent the winter.

In 1953 I returned, again in early June, this time with my wife, Lenoir Britton (deceased), Arthur Schaff and Dr. Jack Major of the University of California at Davis who, with Craig still

in residence, made up the summer crew. Additionally Dr. Paul Hurd, University of California, Berkeley and Mrs. Arthur (Edie) Lachenbruch participated on a part-time basis.

In 1952 and early 1953 there was much uncertainty in ONR as to whether NARL could be continued after the summer of 1953 because the oil exploration program had been terminated and the construction camp which supported NARL functions was scheduled to be closed in September. Max Brewer and his associates, including the Lachenbruchs, were intent on going it alone with the U.S. Geological Survey program and there were others also interested in staying. In the end, Dr. Quam directed the research program to go forward and Director Ira Wiggins, was given the onerous chore of developing small independent working and living quarters for those who wished to winter over and to furnish messing facilities and all other needs. Max Brewer, at this time with three winters of arctic living experience behind him, was very useful in these developments and the winter's operations went very smoothly. Otherwise, everyone present in camp in the summer of 1953 was ordered out by a date certain in early September.

I returned to NARL alone in early summer of 1954 and continued field work on vegetation. The interesting development of this season was that Brewer was anticipating marriage to Marylou Cunningham RN, a nurse at the Barrow Hospital.

It was possible for me to return to NARL for only a few days in the spring of 1954 as I was in preparation for sabbatical leave from my university to spend the coming academic year at Stanford University. The marriage of Max and Marylou had taken place in Barrow during the winter and they moved back to home base in Menlo Park, California shortly after I arrived in adjacent Palo Alto in the autumn of 1954. The Arthur Lachenbruchs had already returned from Barrow to the Geological Survey in Menlo Park and were also living in Palo Alto.

There were many current and former NARL investigators at Stanford University, including Ira L. Wiggins and William C. Steere (not in residence that year); G. Dallas Hanna was just a few miles away at the California Academy of Sciences in San Francisco; just across the Bay Bridge in Berkeley were Frank A. Pitelka, Paul Hurd and others at the University of California; and just about 70 miles northeast was Jack Major at the University of California at Davis. It looked like a grand, cooperative and productive year for us all but proved a fateful one for myself.

The American Association for the Advancement of Science held its annual meeting in San Francisco just after Christmas, 1954. I gave a paper on some of my Barrow research and Louis Quam came out from Washington to hear it but also proved to have other things on his agenda. He invited me to lunch and surprised me with an invitation to take a position in his office as

Scientific Officer for the Arctic Research Program. As politely as possible, I rejected the offer out of hand as I had no intention of abandoning my academic career

Just over two weeks later, life took a dramatic turn which need not be discussed except to say I foresaw an ill-defined future in which my financial needs promised to greatly exceed my faculty rewards. In March I contacted Louis Quam and, finding the position he had offered still available, accepted. Briefly, in September 1955, having resigned from Northwestern University, I reported for duty in the Office of Naval Research. Thus began a fifteen-year period of service to the growth of the Arctic Research Program, including its logistics arm, NARL.

My job was to plan, provide and implement a research program, as much as possible concentrated at NARL, where our field and laboratory resources were focused. Further, to make certain that annually budgeted funds were allocated in a balanced way so that the programs adequately utilized the logistics resources and, on the other hand, that these resources were fully adequate to the demands put upon them by the research. The first of these proved easier of accomplishment than the second and later the reason will be mentioned.

In Washington, Louis Quam and others taught me the ways of conducting the government's business and I brought to him fresh views, based upon what I had learned at NARL, which would improve and enlarge its services to its clientele, the investigators we sent there. My task was the easier because there were so many obvious deficiencies. I had an agenda, often stated, which need not be repeated here, with one exception. Leading my list of priorities was an absolute requirement for a full-time director in full-time, year-round residence at the Laboratory.

In about one year that requirement had been fulfilled. In the order of occurrence, my choice for Director of NARL was identified; Louis Quam accepted my recommendation on its merits and approved determination of the candidate's interest; and by phone call to Mr. Max C. Brewer the matter was discussed and he responded positively to being nominated for the position. At this point it was necessary to proceed with care. Dr. G. Dallas Hanna had already accepted to be Director for 1956 but he recognized the importance of having a permanent Director. He cheerfully stood aside with the promise that he could spend the year at NARL pursuing some special projects which were of importance to him and to the Laboratory

The final, and more sensitive step, was to get the President of the University of Alaska, Dr. Ernest Patty, to accept under his contract for the operation of NARL, a man he had met but did not know, my man as his man, and employ him as DNARL. He came to our office in Washington to discuss the matter, realized the significance of the decision to us and reluctantly agreed to forego his right to select his own personnel in this case.

So it was that Max C. Brewer became an employee of the University of Alaska and a loyal ally of ONR in assuring that the research programs approved by it and sent there for support, whether contractors, AINA subcontractors, grantees, or representatives of Federal Government Agencies, or contractors of such agencies utilizing federal funds, were accommodated with respect to field and laboratory needs. With this appointment both the Washington research program end and the NARL field support end of the Arctic Research Program were secure. It was my hope that we could perhaps be certain of Brewer's services for as much as five years. Everyone in the system knows how lacking I was in vision. In truth, I was to benefit by his able administration of NARL for a tenure quite close to my own in ONR, that is, 15 years. He accepted appointment from the University of Alaska in early May 1956, just eight months after I joined ONR. We were to remain an amicable and steadfast team with common goals until I resigned in September 1970. Brewer departed just 10 months later, in July 1971.

From the outset, following transfer of the Arctic Program to the Geography Branch and to Louis Quam's administration, the NARL was recognized for what it was, a potential center of excellence for the conduct of basic and applied research of U.S. Navy interest. Quite logically this led to recognition that Navy needs and interests in a great many ways were no different than those of either other military departments or of many civil agencies of the Federal Government. Therefore, in a remote area of difficult environment where individual research tasks were not easy to organize and accomplish, the capabilities that existed, or were envisioned to become existent at NARL, must be fully utilized as a national asset, open to all who could legally qualify for ONR support. The Procurement Division of ONR determined legality and, subject of course, to the authority of the Chief of Naval Research, determined whether proposed projects we wished to accommodate could enjoy the services of NARL.

Many kinds of funding arrangements were made with other government agencies in accomplishing their work under the ONR banner. In many cases agreements for support were entered into on a joint support basis in which the ONR contribution consisted solely of the assets available at NARL. In another instance the agreement might be for full reimbursement of costs. The assets were generously shared and it was the difficult job of Director Brewer to make the allocations once he had an approved program. He accepted every challenge of a new support problem with equanimity and, upon being asked if he really thought a proposal was feasible on short notice, would rarely say more than, "well, it will be interesting." In our years of association when I was bringing the problems and he had to face the work at the end of the line, I never heard him say no to a new task and they were sometimes blockbusters. Such willingness was sometimes a problem, and as alluded to earlier, the research sent there at times really exceeded capacity and put too much stress on the Director and staff as well as investigators. As mentioned above, Brewer with his many talents and drive gave me security, and I shall add, ease of mind, and work in the field usually progressed

efficiently and smoothly

On the Washington scene I had another level of security which was much valued. Earlier when offering congratulations to the AINA, I stated I would revisit that subject in another context. This was with reference to services the Washington Office of AINA provided in the form of advice and recommendations on the Arctic Research Program; to organization and operation of special committees, seminars, and symposia; to the compilation and publication of the “Arctic Bibliography”; and the administration, under ONR contract, of a subcontract program of arctic research tasks, principally at NARL. This contract had been established by Louis Quam at about the same time the operational contract for NARL was negotiated at the University of Alaska and it was a source of some friction at the latter. There was an understandable preference to have the research functions vested in AINA at the university instead. Such an arrangement was not feasible as working relationships between the Institute and ONR--the frequency, volume and often the response time of transactions—required the two offices to be near each other.

Either Louis Quam or I, or both, sat in on the deliberations of committees reviewing research proposals, participated in preliminary decisions and finally approved or disapproved of subcontracts recommended by AINA. All expenditures of funds for research subcontracts by AINA required individual authorization and approval by ONR and easy and ready contact between the offices was mandatory. After 1959 this function for ONR was entirely mine when Quam moved to the position of Director of the Earth Sciences Division of ONR. In that position he was always very helpful in resolving major problems but did not participate in routine management.

In 1966 the Arctic Program staff was greatly strengthened when Ronald K. McGregor CDR U.S. Navy was assigned to active duty in the office. When he retired from the Navy in 1968, I was fortunate to be able to recruit him as a civilian scientist. He shared in the management of all aspects of the program and was later to replace me as Director of Arctic Research when I resigned from ONR in September 1970. Louis Quam severed all ties to the program in 1967 when he moved to the National Science Foundation as Chief Scientist, Antarctic Programs, this office later to become the Office of Polar Programs.

The various Directors of NARL were also invited at times to participate in the AINA committee meetings and were often in attendance. As the program grew in volume and diversity and the geographic areas more widespread, both on land and at sea, close coordination of diverse tasks was very important. Brewer over the years became a master at coordination of all elements of the program placed under his care. His views of feasibility of certain tasks were absolutely essential during review of proposals. This necessity existed primarily once each year, in the

periods in which the major program decisions were being made. Otherwise, the constant flow of these types of transactions on a small scale throughout the year did not justify bringing in the Director.

The system worked extremely well but more and more with the passage of time it became necessary to handle all larger contracts directly out of ONR. The AINA had some tendency to resist recommendation of larger more expensive tasks, preferring to spread the available funds around on more and smaller programs. This sometimes brought conflict with individuals and organizations with whom ONR staff had been discussing desirable research and encouraging submission of proposals. Also, many university applicants for contracts chose to apply for them directly to ONR, both because they knew of AINA preferences of scale and also because they knew AINA subcontracts did not permit payment of overhead costs.

The AINA contract remained invaluable for handling a large part of the program. It enabled especially the inclusion of many research tasks which were indeed too small—often for only a few hundred dollars—to permit negotiation of government contracts directly. Often these were tasks requiring primarily the utilization of NARL services and little direct funding. The volume of research accomplished was much augmented by this avenue with little monetary outlay at the AINA level.

John, in explaining my involvement in a meaningful way I have essentially found it necessary to roughly review how the Arctic Program did business and, therefore, how I fit into the Washington and Barrow ends of the system. As I have written those comments I have been reminded of a great many interesting or amusing things about my Iñupiat friends. Most of them, of course, were Barrow residents and among those I knew best were those employed at NARL.

The ones I saw most often over the years were Kenny Toovak, Pete Sovalik, Phil Sovalik, Merle Solomon, Chester Lampe, Adam Leavitt, Joe Ahgeak, Frankie Akpik, Percy Nusunginya and Harry Brower but also I remember well a large number of others. Some, such as Tommy Brower, Al Hopson and Forest Solomon and Charlie Edwardson, Jr, I frequently saw in friendly visits although they had no direct relationship to NARL. The former employees will always be remembered with appreciation and respect for their good services to the Laboratory and all of the investigators. They were all good company and I enjoyed my visits and conversations with them. Here are a few humorous and interesting things I remember which I hope will be enjoyed by Mayor Nageak and his entire Community:

Joe Ahgeak was the only Native employee of NARL who worked with me at times on my research program. He was a very careful and reliable worker and often worked alone. At other times he worked along with me and we enjoyed each other's company. I was very pleased and surprised one morning when he came to me with a big smile and said he was the father of a new son and that he and Mrs. Ahgeak had named him Max, after me. This was an honor I have always cherished and I am happy now, in 1997, to find myself on the same program celebrating an important anniversary with my namesake. I also acknowledge my pleasure now in knowing that Joe's daughter Edna, whom I only knew slightly as a very young lady, having earned her doctorate at Stanford University, is now President of Ilisagvik College.

In May 1965 Max Brewer, John Schindler and I, and several other people from NARL, were in Iceland for the evacuation of 4 ARLIS-II personnel after the ice island had drifted out of the Arctic Basin and down the east coast of Greenland. When the evacuation was safely completed and there was time for relaxation we did our best to show the men a little bit of Iceland in the area about Reykjavik and Keflavik. There were three Barrow Natives among the evacuees, James Itta, Percy Nusunginya, and Frankie Akpik. On one drive with a group including Frankie, when we were, as always seeing grazing sheep everywhere, I teasingly asked Frankie if he knew what the animals were and he with a big smile said, "they are sweaters," He knew what their wool was great for. Later when we saw some lambs I asked what they were and the prompt reply was, "little sweaters" Frankie had had his joke on me. To this day I think of sheep as big sweaters and little sweaters.

Frankie also figured in another well-remembered episode. Rear Admiral Ralph Weymouth and Mrs. Weymouth honored all hands with a large and very elegant dinner party in their quarters. He was the Commanding Officer of the U.S. Naval Air Station at Keflavik and played a very important role in making certain all ARLIS-II men were safely brought into Iceland, comfortably cared for, and honored for their exploits. Our charming hostess, Lo Weymouth, selected Frankie to be the guest of honor. This honor gave Frankie the privilege of sitting at the right of Mrs. Weymouth at dinner and, therefore, gave him the opportunity to be attentive and entertaining to her. He was the perfect gentleman and made us all very proud of him. Mrs. Weymouth later commented to us that she found Frankie very poised and a very pleasant conversationalist about many interesting things in his life and work in Alaska.

One summer after I had gone to work for ONR I visited NARL on one of my periodic business trips and wanted to see Jesse Walker who was working on his research over on the Colville River Delta. One day Max Brewer had to send a plane on a supply mission over that way and let me ride along with Joe Felder as pilot. Max asked me to drop off a case of celery for George Woods who apparently had a great love for it. The celery was delivered and, since Walker was up river working and not available to me, and the airplane would not restart, I had the opportunity to spend a very pleasant afternoon

with Nanny and George Woods, just talking and having tea and cake. Ultimately Felder got the plane started and came to the house to announce we could depart. Suddenly George asked for a few minutes time and ran out of the house. He returned with a huge frozen fish which he handed to me and said, "Max please take this to Max, he's such a dear boy." That comment really cracked me up. Max got his fish and the message but I did not feel compelled to agree with George's assessment.

*On another business trip I was wandering around the various NARL facilities taking stock of what was going on and stopping to visit at times with investigators. Passing the animal colony I found Pete Sovalik mucking out the fox pens and not seeming his usual cheerful self. He indicated he was dirty and smelly and could not shake hands. As he stood there, obviously upset, shaking his arms and hands to rid them of debris, he turned to me and said, "Britton, this is no job for a **man**. The emphasis is mine but I think that was exactly the message he was sending. He was a proud man and one of my favorite friends.*

To Mayor Nageak, I wish to say that I am very much looking forward to the August celebration and to the opportunity to meet him and others for the first time, as well as to see all of my old friends. It has been 27 years since I left ONR and my responsibility for NARL. I have been back to Barrow briefly on only a couple of occasions. I hope then everyone knew Mr. Ronald K. McGregor who became Director of Arctic Research after I resigned and was then often in Barrow. I hope this letter will remind you of the past history of the Laboratory, including my own roles, which may have been forgotten or perhaps not previously known.

Before closing, I wish to say that I am very proud of my opportunity to serve NARL and to have, therefore, perhaps in an indirect way, served Barrow and its residents as well. As has now been said several times, I had to find a leader for NARL who had a certain combination of traits. I found those traits in Max Brewer. One trait that especially appealed to me in our earliest contacts was his spirit of generous, unflagging helpfulness to me and others. Although he was away in the early part of my first summer at Barrow, thereafter he was a patient mentor for me in the conduct of my local field work. In 1953 he was in his third year in the Arctic and had learned well, perhaps more from the citizens of Barrow than anyone else.

My next priorities were simple and pragmatic: arctic experience, availability for continuous, longer-term residency, and youth. Scientific background was essential but secondary to other traits. Brewer was a competent scientist and destined to grow but very much junior to all but

perhaps one of his predecessors. This was a factor I had to deal with among others who could negatively influence my decision or even some who either saw themselves or friends as having superior scientific and academic qualifications for the position. Privately, I was content with his status and stature as he had all of the attributes of my principal priorities and I had no other candidate who did. He was a perfect candidate for me. Academia was well provided with scientists who could have been had as directors on the basis of the time-honored method of DNARL selections, but times were now changing.

A resident DNARL annually met and worked with a great diversity of sciences and their practitioners. The Laboratory was a fertile educational field. Brewer was an apt student and in the course of a few high intensity years became conversant with a large and diverse number of sciences and the peculiarities of their support needs. The skills he developed made him a superb coordinator of the research programs we sent to him. It is recalled with pleasure, his triumph in coordinating a famous, elderly Swedish plant taxonomist, who had low tolerance for Swedish lady scientists, into the same Cessna on floats on many a field trip with a delightful lady Swedish scholar. She was not offended only amused by her countryman and went happily about her study of certain little lake-dwelling animals. It was that or nothing if both were present and waiting for plane time. On other occasions Pete Sovalik was the lady's favorite companion and assistant in the field.

Quite aside from Brewer's unquestioned competence in his own scientific field, to me it was on-the-job-training of the generalized type mentioned above, that made him outstanding compared to his predecessors, and that in no way implies criticism of any of them. Length of service on the job counted.

The Brewers left Barrow in 1954 and, as a consequence of the events discussed above, were back as part of the Barrow community in 1956. As a family they reared five children, who shared the lives of the people of Barrow and attended the very good public schools. Max organized his own domain and selected and hired his staff. His own position was the only one I ever attempted to influence at the University of Alaska. His hires included, as you know, John Schindler, as Assistant Director. They served together for about a decade with John succeeding Max as DNARL in 1970. Had I still been on the job, I wonder if I would have backed down Dr. William Ransom Wood, then President of the University of Alaska, in a debate over a different candidate for Assistant Director. We will never know, but there would have been no occasion—Schindler had learned and he had earned his spurs.

I wish to interject at this point a few important comments about President Wood, as he was quite important to the reputation of the Laboratory on the university scene and in Alaska as a whole. He inherited some dissenting voices when he became Principal Investigator for the

ONR contract but they never affected his judgment as far as I could discern. In fact, he loved the Laboratory and all that was done there and all of his employees there as well. He thought the Laboratory was a great asset to the university, and when before the State Legislature, blushed not a bit when essentially taking personal credit for everything good that ever happened there. Now President Emeritus and long in retirement, I hope his face will be seen in Barrow in August. In 1965 he showed his high regard for Max Brewer's contributions by awarding him one of the University of Alaska's highest honors, the Honorary Doctor of Science Degree. In nine years of exemplary service, he had earned it.

John Schindler brought his wife Erna and one baby daughter to Barrow as soon as he could and they too sent two children through the Public Schools and enjoyed the Barrow life just as did the Brewer children. These were wonderful experiences for all of these people and I am sure have left nothing but happy memories with them for all time.

The point I finally wish to make to Mayor Nageak, is that the interrelationships these, and other families and many individuals, had with the Barrow people must have been of tremendous benefit to all I know they cooperated with the Barrow people and did everything they could to be good citizens and to insist that all NARL workers also be good neighbors and citizens. I was in the area very often and know of many of the ways in which Max and John did helpful things for all of the Iñupiat in every degree possible. Even more, I learned more and more of our debt to the Iñupiat people for their teaching and their help in countless ways. Until someone instructs me differently, I shall assume that all of these interrelationships must have had a very great bearing on the very original Borough development of its own college, its own research, and the continuation of research support facilities for others. If my associates there did play such roles, I shall claim that in a small way I indirectly helped also. I think Bill Wood would do the same.

John, now a final word to you. I hope Ron McGregor, or some other, is presenting a similar letter to mine with regard to NARL events extending from the Schindler administration through your own. I know some large and excellent programs were carried out and I shall assume there was an increase in excellence every step of the way. I have never heard the story and I should be delighted to do so.

In closing, Vera joins me in sending her very best regards and good wishes to you and Eleanor. As you know, the Arctic Institute was her first place of employment when she came to this country in 1953, and she played an active role in arctic affairs. She assisted in conduct of meetings at times, including at your university and at NARL. She stayed there until 1970 and still retains a great deal of affection for the Institute, especially for the memory of Admiral L. O. Colbert who, as Director, gave her her first position when she came to the United States. She

regrets very much that she will not be able to be with us at the August celebrations.

With all best wishes to you and Eleanor.

Sincerely,

M.E. Britton

Sylvia Ciernick Broady

June 15, 1997

Dr. John J. Kelley
The Arctic Institute of North America
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P.O. Box 756808
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Dear John,

I am pleased and honored to be included in the remembrance of the 50th Anniversary of NARL. Though my involvement and remembrances are mostly personal, rather than professional, I have always felt privileged to be a part of the important work of the Naval Arctic Research Laboratory. My recollections will also be those of Tom (Steve) Broady, my husband and the reason for me being a part of the NARL team for two and a half years. Sadly, Tom died in 1992 and cannot recount in his inimitable "Broady" fashion NARL history.

FOR THE RECORD I lived at NARL from December 1966 to the summer of 1969 as probably one of the very few wives in the "camp" who did not work in some capacity. I was a new bride who had just left the University of Alaska as its Director of University Relations and coveted the leisure time to read and experience my new environment.

Tom arrived in Barrow three years earlier on a July 5, 1963 Wien flight directly from a project in Indonesia. He wore a straw hat and wondered where he could hide it as he looked at remnants of snow on the ground and a parka-clad welcoming committee. Even more incongruous to this southern gentleman was the exuberant baseball game being played on a field ringed by snow.

Tom was the new Project Manager for the Vinnell Corporation which had just received the contract from the U.S. Air Force to provide all of the logistic services for what was affectionately called the "Camp" where NARL was located. He served as project manager from July 1963 until July 1969, when the management contract was awarded to the Holmes and Narver Corp.

Maybe it was Tom's years working overseas with many different cultures, for he quickly became a part of Barrow life and established living and work procedures that encouraged the hiring of Barrow villagers and respect for their customs and unique skills. He worked

hard to increase his company's involvement in, and support of Barrow community activities. And, most

importantly, he worked to ensure that those in the work force from the "outside" (teamsters, electricians, cooks, etc.) did not negatively impact village life. The Village and the lab lived in a symbiotic relationship, which the harsh Arctic environment made sure everyone understood. Each depended on the other. Life in the Arctic at that time was once-a-week air service (later twice a week), one annual resupply ship, dog sleds as the common form of transportation, and a few trucks used by the various government agencies and contractors.

Providing support services really meant running a self-contained community complete with a gas-fired boiler plant that heated many of the buildings, a central mess hall, a small dry cleaning plant (parkas do get dirty), an air strip, a company store for sundries, fresh water distribution, road maintenance, vehicle maintenance, a gymnasium and living quarters for everyone. All this to support the research mission of NARL. Barrow villagers were an integral part of the work force for this isolated community.

Tom frequently talked of the interdependence of everyone living in the Arctic, and found it irrevocably illustrated by the "storm of October '64 [1963]" when the fall wind storms raked the coastline before the ice froze to protect the shoreline. Quonsets were ravaged and moved from their footings more than a city block and the camp temporarily evacuated to the Dew Line site. Rebuilding the camp and the Village became a joint effort of the Village, NARL and Vinnell. The storm filled the nearby fresh water lake with salt water and from then on all fresh water was hauled to the camp by "Cat-train" from a fresh water lake seven miles away. During his tenure as project manager Tom's crews re-built the camp airstrip, provided logistic support for the drilling of the first gas well to serve the fuel needs of Barrow Village and assisted in the construction of the first NASA missile launch site above the Arctic Circle. The men employed from the village may have learned new trades and skills, but they taught everyone else the skills needed to do it in the Arctic.

Tom arrived in Barrow a bachelor and left a married man. But before we were married some of the Barrow men felt that in the Arctic no one lived alone. Everyone needed a mate and they worried over this vigorous man whom they had come to like. Tom's protestations that he enjoyed living alone were ignored. As the elders became more concerned they took action. On a particularly clear moon-lit night two dog teams arrived at Tom's Quonset with several men and an obliging Barrow woman who would keep house for Tom. After much conversation they all returned to the village and Tom continued to live his life alone. But Tom's bachelor days were soon numbered.

My first trip to Barrow on March 14, 1964 was in one of NARL's R4Ds. I was assigned a seat on a bale of straw destined for the lab's animals. I had four

days to familiarize myself with the activities of NARL so that I could report and write about them as part of my responsibilities to publicize research at the University. Never did I imagine that some two years later I would be returning in a cold, dark December to spend my honeymoon in a Quonset hut.

On this first trip Jack High loaned me his parka, which was only two or three sizes too big. But the insulated pants from the NARL wardrobe room swallowed me up. I always thought it was Max Brewer's intention to obliterate all signs of curves. Apparently he didn't succeed because it was on this trip, on the Ides of March, that I met Tom. Two years later we were married in Anchorage on Dec.17, 1966.

Most people go to warm climates for their honeymoon. But Tom and I chose Barrow, AND we chose to invite my mother, a widow from Michigan, to join us. Not many take their mother/mother-in-law, on their honeymoon. But we did. This caused much consternation among the men working for Tom. Mom's gray hair matched Tom's and mine was blonde, making many of the men not sure who was the bride. They solved one problem quite ingenuously. We gave my mother Tom's large Quonset hut and took a smaller, half-Quonset as ours, knowing we would join mother during the day. Leaving mother in the big Quonset, we arrived at our temporary honeymoon quarters, to find on the coffee table a chilled bottle of champagne, a welcome note, and THREE champagne glasses. Tom looked pleased because he always advocated planning for any eventuality - even mothers-in-law.

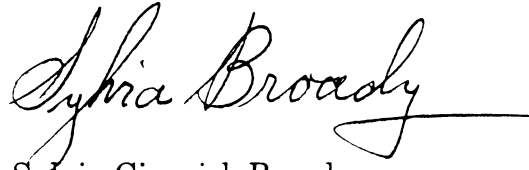
With large portions of my day free for the first time in my adult life, I began to voraciously make my way through Tom's extensive collection of books on the Arctic, writers like Peter Freuchen, Charlie Brower, Vilhjalmur Stefansson, Diamond Jenness and George Wilkins. My best reading was done on the days polar winds and snow swept over the Quonset and a piercing cold draft invaded the Quonset floor boards designed by the Seabees for tropical living. Reading truly involved all of the senses. There was something skin-tingling about these sound effects accompanying the printed page. And they always managed to match the mood of the text.

What do I member the most? Reading all of those books while experiencing the environment in which they were written. Learning directly from the wisdom of the village people who may not have tamed their environment but developed ingenious ways to make it work for them while not upsetting the balance of nature. Watching everyone in the Vinnell support group and in the scientific community of NARL develop a respect for the abilities and values of the permanent residents of Barrow; wonderful individuals who graciously and openly welcomed us, guided us in their Arctic world and unfailingly put up with our naiveté and stereotypes as we lived in their culture. Their support was so complete and unassuming, so giving without caveats attached. I have never felt more welcomed.

It was with great sadness that Tom and I flew out of Barrow on July 1, 1969 on the first Wien propless jet to serve Barrow.

But is also reassuring that the work of NARL continues. I want to congratulate the North Slope Borough and its many entities for providing the leadership and means for the lab to continue its pioneer work into the next fifty years. Research in the Arctic only increases in importance.

Sincerely,

A handwritten signature in cursive script that reads "Sylvia Broady". The signature is fluid and elegant, with a long horizontal flourish extending to the right.

Sylvia Ciernick Broady

Follow-up: I later continued my work with the University of Alaska at the Anchorage Campus as Professor and Chair of the Journalism and Public Communications Department, leaving academia in 1995 as professor emeritus. During my 32 years in Alaska, the time in Barrow with NARL was the most stimulating and rewarding.

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Jerry Brown
P.O. Box 7, Woods Hole, MA 02543

June 17, 1997

Dr. John J. Kelley
Arctic Institute of North America
Rasmuson Library
P.O. Box 756808
Fairbanks, AK 99775-6808

Dear John:

This is a short reply to your request for letters of remembrances to commemorate the 50th anniversary of NARL. I plan to present a report and photographs in August at Barrow so I will be brief and hopefully to the point.

This year will mark my own 40th anniversary since I arrived at Barrow in June 1957 as an undergraduate from Rutgers. For the next three summers I passed through Barrow to the Brooks Range to conduct research for my doctoral dissertation. I was hired by CRREL in 1961 and returned to Barrow for an intensive four-year research program. After a short absence the inevitable occurred with a return to Barrow in 1969 to begin the IBP Tundra Biome and followed by the RATE program. The late 1970s and 1980s took me to Prudhoe and the haul road accessible from Fairbanks, and seven years at NSF. I returned to Barrow in 1991 as a retiree to continue with colleagues on the ARCSS program. I should also mention that Celia and I managed a short honeymoon at Barrow in 1965 and returned with two sons in 1969 (enclosed are two of Celia's poems inspired by those experiences).

None of this would have happened without the early ONR-supported research program through AINA and the then "free" logistics. I first came to Barrow on the AINA grant at Rutgers under J. C. F. Tedrow's program and Lowell Douglas' soil respiration study. My own thesis research and graduate fellowship was supported by the ONR-AINA-Rutgers grant. Both CRREL and NSF played significant, but later, roles. I have always felt deeply indebted to ONR and AINA for starting me on my arctic career.

Throughout my Barrow-centered research career, I was supported by NARL and the Inuit communities of the North Slope. This support has been invaluable and memorable. I look forward to sharing these memories in August and seeing many old friends. Thanks for undertaking this documentation of the NARL generations. Don't forget your own letter.

Sincerely,

Jerry Brown

Celia Brown
P O Box 7
Woods Hole MA 02543

Arctic Summer

Now while fireflies sequin the south
The midnight sun smiles poleward.
Beach ice breaks up in cold water
Leads. Wet reeds splinter into nests
For tern and the loon. Foxes watch
Vixen watching voles.
Polygons poppy out in yellow.
And while lichens splurge on purple,
Stems nudge lemmings in
The food chain, even the lowest
Grasses flurry out in cotton
As the snowy owl dines.
Only whirling geese remember winter.

Lament Of A Tundra Wife

I was out there gathering blooms.
He had hunkered down over his work
While furry things burrowing,
Slid underfoot: brown ones, grey ones
Dark ones, fawny ones, mean ones,
Green ones, cute ones, tawny ones,
Scampered all over his data.

Not that my husband noticed-That I rode on the back of rat,
Or might take the next flying leap,
A mad little hopscotch with lemmings
Bound for the Beaufort Sea—

As he studied permafrost,
At thirty balmy degrees.
As if long before I had followed him
There, the North had raised
Him in its hand.

I remember how the walrus sunned
Himself, how geese rose oft with purpose,
How the lemmings disappeared,
Imperceptibly as the summer,
Or the flower I had pressed in a book.

Beaumont M. Buck
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6/13/97

Dr. John J. Kelley
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Dear John:

This is in reply to your letter of 28 April 1997 asking that I submit remembrances of my work at the lab on its upcoming 50th anniversary. I am sorry that prior commitments preclude my attending the event, but I will be happy to share some reminiscences. Using the format you suggested:

a) My involvement and years at the lab:

I was Project-Officer in the Undersea Branch of the Office of Naval Research in charge of the (then) new development of the first digital sonar, called DIMUS. This was in 1957-1961, during which time the nuclear submarines NAUTILUS and SKATE operated under the pack ice of the Arctic Ocean engendering considerable navy and public interest in that area. Guy Harris, Technical Director of the navy's Underwater Sound Lab in New London (USNUSL), and I put our heads together and came up with the idea of building the first DIMUS and taking it to the Arctic in the winter of 1959-1960 to operate with SARGO, the next sub scheduled for an Arctic cruise. I would arrange funding and see that the DIMUS sonar was built by the Marine Physical Lab of Scripps and would act as Officer-in-charge of the installation on a floe station (charlie, I believe it was) in January, 1960. Harris would crank up the USNUSL technical apparatus and provide the ancillary equipment to make the DIMUS into a super surveillance system, many years ahead of anything existing in the open oceans, and provide four arctic-seasoned personnel to aid in the installation and operation during SARGO's cruise. NARL was to provide two native workers to aid in the considerable chore of ice drilling for installing the 48 hydrophones of the giant array. The floe station started to break up and was abandoned just before our scheduled departure and it was

decided to shift operations to the USAF station on Ice Island T-3. However, it was recognized that we would have no chance of drilling 48 holes through the ice island using existing ice drilling technology and therefore would have to use the thinner sea ice covering nearby Colby Bay.

The USNUSL crew and I were flown directly from Ladd Air Force Base in Fairbanks to T-3, skipping Barrow and my chance to see NARL. But I met NARL's representatives, Eddie Hopson and Frankie Akpik on the ice island. This was my first meeting with any Eskimos even though I had read much about them. It was an association that would continue for many years and one that I consider to be among the most pleasurable in my professional life. The drilling operation was carried out under conditions that even Eddie and Frankie admitted to be miserable in the extreme. I was later to learn that the Arctic Ocean could be warm and windy, or cold and calm, but seldom both cold and windy ... except at ice islands, and January 1960 must have set records even for those big lumps of ice. Also, we found that Colby Bay sea ice was much thicker than had been reported and most of the holes had to be drilled through 18 to 20 feet of ice. Never the less, we got the job done, and in time for SARGO, Thanks to Eddie and Frankie.

I purposely made this preamble rather comprehensive because it sets the stage for my 28-year involvement with arctic acoustics that followed. Despite heroic installation efforts, the digital sonar we had in 1960 did not work right due to a miss-wiring in the lab and it took us 28 years to get it right. Eventually though, we not only made it work, but determined how well it worked (a considerable effort in itself, considering the vagaries of Arctic Ocean environmental factors by season and geographic location). Eighteen of those years were involved with NARL (1960-1978). After the T-3 experience my next association with NARL came in 1964, after I had left the naval service and had gone to work for General Motors Defense Research Lab in Santa Barbara. We set up, with the considerable help of Pete Sovalik, NARL's Chief Guide, the first US small scientific ice camp on sea ice (that was more than just a day-camp with the planes remaining on the ice) about 150 miles north of Barrow that year and started a series of yearly, quiet acoustic camps that continued until 1988. Again with NARL's help (primarily the Twin Otter flying of Pat Walters), we set up and manned in 1977 the first U.S. ice camps in the Eastern Arctic that

were to serve as the pilot experiment for the large East Arctic Program that ran from 1979 to 1982, based out of Word, Greenland.

Besides our work in the Central Arctic Ocean, we maintained full-time research stations in the Bering Straits for the study of shallow water surveillance acoustics in the '60s and '70s. This effort received partial support from NARL, (primarily aircraft services for acoustics experiments and some special flights for ferrying personnel and equipment to Cape Prince of Wales and Gambell). Our involvement at NARL became so considerable in the early '70s that we hired a special technician (Dick Heymann) and installed him full-time at NARL to keep track of our field equipment and to interface with the lab on our requirements.

b) My remembrances of associations with community residents, and
c) Anecdotal stories of interest

I remember many people at NARL that made strong impressions on me that will last a lifetime, but I will confine my remarks here to those who resided in the Community. If I leave anyone out, blame it on an old man's memory. But, even if I were a hundred, how could I forget Pete Sovalik? I got to know Pete at the first U.S. small ice camp: GMIS I (General Motors Ice Station No. 1) in 1962. Bobbie Fischer and Bobbie Main had landed us (myself and Dan McDonald) in their Cessna 180s on a refrozen lead and stayed long enough to see us attempt to install a special tent we had brought from sunny Santa Barbara. A crucial part shattered in the -40 degree cold and Bobbie left us his emergency tent before he shoved off. Disdaining that (it had mosquito netting!) we built what Pete later told me was a "kayleon" that hunters sometimes used... a twelve foot diameter, four foot high, vertical-walled cylinder of snow blocks with the remnants of our tent anchored over the top. (Actually, it was pretty comfortable.) Bobbie went back to NARL and told Max Brewer about our plight and Max sent him back the next day with Pete, a case of beer and a World War I wall tent that was bleached white over many tundra summers and had seen better days. Dan returned with Bobbie to NARL and Pete and I settled in for two weeks. By the time we finished the case of beer and Pete had almost been caught out from camp without his rifle by a polar bear, we got to know each other pretty well and became fast friends. One of my lasting memories of Pete is him looking down and shaking his head side to side, saying: "My old daddy always told me, 'Never go even

ten feet from your ice camp without your rifle!" And, I remember his many hunting stories, including the one about a man trying to kill another with a copper bladed hunting knife and having to straighten out the tip with his teeth while he held the other man down. And, one about the polar bear killing and eating the mother in a snowhouse, but not touching the baby strapped to her back. I believed all his stories then; I believe them now Pete was above lying (even over a beer or two).

I have often ruminated about the men I have spent time with on the ice and wondered who I would most like to have with me in an emergency. It came down to three: Pete Sovalik, John "Jumper" Bitters and one other. I salute all three.

Let me summarize what I thought of Pete. I consider myself a well-read person and I have seen many definitions of the word "gentleman." Pete met every criterion. I never knew a man who was more of one than he. Moreover, he was not just a gentleman; he was a gentle man. What a heritage he passed on to his offspring! Those that remain today must be awfully proud.

Bobbie Fischer was the chief pilot of NARL in the early days, and a resident of Barrow. I remember how proud he was of his new house, which was the first two-storied one in the town, and of his very beautiful wife. I trust that she and Bobbie's children are well and happy. Over the years, I have flown with a lot of good pilots, and some not so good. I would rank Bobbie among the top three in terms of all around flying skills. He and I frequently flew out from one of our ice camps in order to land and install some instrumentation, or drop an explosive sound source. I remember the spring of 1963 when Bobbie came out for one of these exercises. We loaded up and took off. When we had climbed to cruise altitude, I asked him if he wanted to play our usual game of betting a beer on his estimation of ice thickness where he would choose to land. If he was more than a foot wrong, either too thin or too thick, he would owe me a beer, otherwise I would owe him one. I never collected on any of these bets. His knowledge of the sea ice was uncanny. It had to be, to survive this type of flying for the years he had been at it.

And, I remember the perennial NARL men on T-3: Jimmy Cressman and his sidekick Charlie Hopson. Jimmy was a genius at anything mechanical and helped our projects along tremendously, and

especially when we got into real trouble. Charlie was scrappy as a wolverine, and a bundle of energy keeping the whole installation on T-3 humming.

Kenny Toovak was in a class all by himself. Master machinist, inventor, designer and problem solver extraordinaire. I don't remember a trip to NARL where Kenny did not help us out of some problem or another that no one else was able to solve. Once when Don Johnson and I were trying to drill a hole through T-3 using a new-fangled drill we had brought up from the states and were having a hard time making it work, Max Brewer sent out a hot-water ice drill that Kenny had designed and built. It probably would have done the job if Max could have spared Kenny and sent him along with it. Alas, he did not, and Don and I proceeded to melt down the insides before we got the hole down a foot. (We did finally get our drill to work - the next year - and drilled over a hundred holes through T-3 with it.)

May I make a concluding remark that is really an opinion that will have to remain unsubstantiated? To all of the above natives of Barrow and the rest I have failed to mention, but helped us at all of the ARLIS camps (III, IV, V, and VI) I say this: Thanks to your support, our Arctic acoustics program ended in resounding success and shortened the Cold War. (If there are any who read this who care to argue with that opinion, bring your clearances and need-to-know and let us discuss it.)

A handwritten signature in cursive script, appearing to read "Beau". The signature is written in black ink and is positioned below the main body of text.

From: busingr@ra.cgd.ucar.EDU (Joost Businger)
Subject: 50th anniversary
To: ffjjk@aurora.alaska.edu
Date: Thu, 12 Jun 1997 22:04:04 -0600 (MDT)

June 6, 1997

Dr. John Kelley
The Arctic Institute of North America
P.O. Box 756808
Fairbanks, Alaska 99775-6808

Dear John,

Many thanks for your letter. It has been a long time since I was in Barrow and I am not sure that I remember how many trips I made, nor when they were, but a few tidbits that I do remember may be useful.

When I came to the department of Atmospheric Sciences in 1958 (it was then called the Department of Meteorology and Climatology) the chairman, Phil Church had been involved with the IGY (International Geophysical Year) which included an Arctic program. This program was continued after the IGY and called Husky. Frank Badgley and I were asked to supervise what was going on, which meant that we would take turns visiting the Arctic, so basically every other year I went North, starting around 1960. The trips were mainly in the winter because the days were short and it was cold. The first time I arrived I was impressed by how inadequate my clothing was, but this was no problem because NARL provided boots, socks, parkas, and pants of such quality that you felt comfortable at 40 below zero. Also the food was of the highest quality and appropriate for the climate.

I don't remember much of the research that went on during my early visits. We basically tried to get profiles of wind and temperature and the recording often gave serious problems, because the strip chart recorders were not designed for the Arctic. In fact very few instruments were. Arne Hansen did something creative with the strip chart recorder but I forgot the details, may be, Ken Bennington remembers.

Talking about Ken Bennington, I assume you have him on your list as well as Charlie and Nancy Knight. At one time there was a program carried out on the ice by Ken, Charlie and Arne, which was partially oceanographic. Ken had asked me to provide some bottles for water samples and noted that the Heineken beer bottles were just the right size. It was, of course, silly to send empty beer bottles. I contacted the Heineken distributor and asked him if they could provide a few cases of beer for an oceanographic experiment. No problem. But when the beer arrived in Pt Barrow, Max Brewer was afraid that such a deal might harm the reputation of NARL. I think in the end the bottles were used properly.

Then there was ARLIS. Pal Arya and I were going to operate a sonic anemometer, which was put together by Fred Weller. Fred begged to not have to go to the arctic, so Pal was coming instead. It turned out that we never got the instrument to work properly. However, Pal was sufficiently impressed by the ice flows and pressure ridges that he wrote a good paper on the effect of pressure ridges on the drag coefficient. It was impressive to see all that was going on at this floating station.

The most successful experiment that I was involved with was the lead experiment. It was a joint experiment with Oregon State University where Clayton Paulson has a faculty position. Ed Andreas was Clayton's student and Ron Lindsay was my student. There were two helicop huts involved, which were picked up by a helicopter and placed on either side of a freshly opened lead. It was so designed that within a few hours the instruments were set up and the data collection could start. The speed was important because the leads may freeze over quickly. Later, seawater was pumped on the ice and an artificial lead was created. This worked the best and the results were quite interesting. Ed got his Ph.D. thesis and Ron got his masters thesis out of this. I believe that this experiment was carried out in March and April of 1974.

I remember that it always was pleasant and interesting to talk to residents of the local community, but I don't remember any anecdotal event. All that is left here are a few artifacts, such as a little drill that is still displayed in the house.

I hope the celebration is going to be a great success.

Best wishes, Joost.

Ben J.Cagle, 10992 Canyon Hill Lane, San Diego CA 92126-2056:

Congratulations on the Fiftieth Anniversary of NARL. I was always eager to come into Barrow and sorry to leave. I have many happy memories; some are given here:

Since I was assisting in the supply of ice camps, the Lab Director decided I should learn something about sea ice. Soon, I was following in the steps of the greatest teacher known [*Pete Sovalik*] – an elderly gentleman from the Village who, among other things, tended the caged polar bear. That increased my respect, and soon I was admiring his endurance as we climbed ridges north of the Lab. He taught me how to find the blue ice and to recognize pockets of salt and undesirable things. Later, in working with him, I was fascinated by his sharp and detailed memory of the many lakes and lagoons east to and beyond the Colville.

Another friend who had great respect for the knowledge and memory capability of Villagers was my good friend and mentor, Arnie Hanson. Arnie logged over ten years on the ice, and his observations of ice phenomena were recorded in black-and-white photos he carefully took with natural lighting enhancement. We spent happy evenings together in the Lab poring over his photos and discussing how the exotic features of ice had formed.

We were preparing for AIDJEX, and there was a lot of activity. People returning from flights compared progress and spent evenings planning next day's work.

It was spring, and polar bears were on the move. The census taker was flying daily. He counted and marked each bear he saw – that is – each bear he was able to tranquilize by a dart in the rump fired from his modified shotgun pointed out the window of his helicopter. (How he did his work, and the many escapades he experienced is fodder for another story.) Enter the drama of one memorable event:

Someone brought in an orphaned cub (minus mother, who, it was said, didn't make it past the Village), and the census taker returned from a successful day over the frozen ocean. Whose idea, I do not know, but the census taker agreed to the experiment. So, the next day's flight carried a passenger – the polar bear cub. The census taker returned to yesterday's hunting area and found the well-marked mother and cub he had entered into his log the day before. This mother got the dart in the rump a second time (which can make a polar bear humiliated and angry). But motherhood is stronger than rage – read on: After suitably modifying the odor all around (How do you do this on the ice? Add a thermos of tea and do like the wolves do. Mark the objects of your attention. Feces from the mother enrich the fragrance.) Soon, mother, her cub, her adopted-cub-to-be, and the census taker had the

adoptive fragrance. Not wanting to be adopted too, the census taker hastily departed without the orphaned cub. The next day, and some days following, he flew over the hunting area and noted a well-marked mother with two cubs. From which he surmised that mother polar bears can smell, but can't count.

The Lab had an extensive collection of left-over items once tried and discarded - the makings of a museum of ideas for work in the Arctic. It seemed every building had some vehicles and equipment sitting outside and around back. Here is how one came to be:

There was a rising interest in coastal oceanography in the Chukchi and Beaufort Seas, and discussions were had with Villagers who knew the most about this subject. They had experienced its secrets and treacheries. Ice loomed as a challenge to applications of modern oceanographic techniques. So, in August, 1995 [1975?], Navy SeaBee officers and I studied data and interviewed experts working in the area. We flew in the Twin Otter recording shorelines from Barter Island to Point Lay. Shallow water, gravel bars, and lagoons were often observed, and we decided to consider these features as an opportunity rather than a hazard.

This was the summer of the big barge lift to the North Slope, so the Navy ice observer was sometimes with us, and we helped out by noting ice movement for the barge lift manager. We compared notes at night in the Lab. When flying, we could almost measure the severity of ice movements by the colorful language of tugboat captains when we contacted them on the radio.

In jam sessions at night with experts and advice from Villagers, we drew up specifications for an oceanographic ship. It must be stable with a large payload and have shallow draft; it must be capable of high-speed dashes and have propellers ("wheels" to tug boat captains) that can be lifted clear of the water on a moment's notice. This latter requirement was to provide escape when the ice came in. The SeaBees had experience running for shore, sliding over a sand bar, and coming to rest afloat in lagoon. The same maneuver could get them out again.

After this expedition, we soon found a small ship that met the requirements. It was an experimental warping tug propelled by two large diesel harbormasters that flipped when their "skag" hit bottom. The ship was made of aluminum and had a draft of less than three feet - even though the space and payload were large. I followed its modification for oceanographic work and prepared it for shipment to the Lab. Engine maintenance problems made it impractical, and it joined the museum outside the Lab.

Ben Cagle

(retired from ONR)

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CURE NOT CARE®

March 17, 1997

Dear Friends of NARL:

I spent the summers of 1958-62, and 1965 at the Lab. The first work was as part of my thesis on the thaw lakes for Iowa State University under Keith Hussey. The latter was for my own research on C-14 dating of thaw lake strands. A number of papers were published and I believe I have sent copies to the Lab.

The Laboratory under the direction of Max Brewer was a very active and exciting place. Both he and Max Britton of the ONR saw to it that the researchers were well supplied and supported. Interaction between disciplines was encouraged and a great camaraderie grew up among the various researchers and between them and the laboratory staff. Many of these acquaintances and friendships persist to this day.

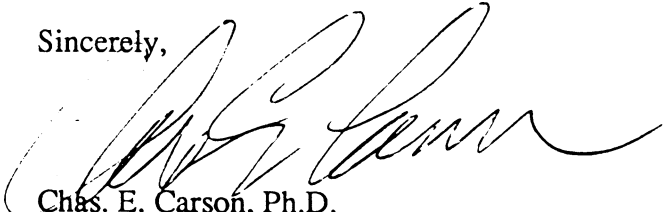
I have especially pleasant memories of the native lab personnel as well as of Dr. Brewer. They did everything possible to insure that our needs were more than met and I came to admire their great qualities as people. Brewer always deferred to the native personnel on matters of knowledge about the environment and wildlife of the area as well as about native customs. This eliminated friction and no doubt saved a lot of naive investigators from accidents and disasters. Of the lab personnel I recall with special affection were Pete Sovalik and Ken Toovak. They put up with a lot during all the expeditions and drillings through the permafrost. I always felt they knew more about animal behavior and the arctic environment than all the researchers combined.

Another person I greatly admired was the Lab's Chief Pilot, Bobby Fischer. He was a fine man and a great pilot, and it saddened me many years ago when he was killed in a freak accident. We flew many a mile together in all sorts of weather, most of it bad. A particularly humorous incident, to me at least, occurred on a short flying expedition to Ikroavik Lake. A visiting fireman, a Naval officer, wanted to go along while we dropped sacks of dye into the lake and then photographed the currents. I said fine, he could help out. While Bobby flew, Navy's job was to sit in the back seat of a Cessna 180 and hand me sacks of dye where I could throw them out from the front seat. To assist this the door had been removed on my side. We would dive down on one shore of the lake, turn on our side, the Navy man would hand me a sack of dye over the back seat, and would drop it out. Then we would swoop up on the other side, fly back over, and flip the plane on its side for another pass. This same process was repeated for the photography. After a half an hour or so we landed back at the airport. The Navy guy staggered out of the airplane, pale and shaking. He swore that he would turn us in, saying he was never so scared in his life. But Brewer got him calmed down. We were young then, and never thought much about danger. Actually, with Bobby Fischer flying we were all perfectly safe. I told the Navy man he should stick to sailing.

I can recall many other incidents, both humorous and tragic. One especially sad time was the search for 6 little native boys who wandered away from the village going, they thought, to their father's camp at the coal mine on Meade River. We were camped on Ikroavik Lake and their playful shouts on the tundra that evening attracted our attention. They were only just little fellows, maybe 6-7 years old. We asked what they were doing and they laughed and said they were going to see their fathers. Not knowing of anyone else around we told them to go back to the village, which could be seen across the tundra. We were going to take them back, but they said they would go home now and started in that direction. However, when out of sight they must have turned or gotten lost because at 2 AM the village marshall stopped to ask if we'd seen them and for our help in the search. We spent the rest of the night and part of the next day in our weasel searching the tundra, Hussey and I, until they were found. Even though it was summer all had died of exposure. Somehow they had gone around our camp and continued on south until one by one they became exhausted.

In general, despite a few sad incidents inevitable in a harsh environment, I have many pleasant memories of the Lab, Barrow, and all the people I associated with there. It was an invaluable experience in the heyday of government support for pure research. I don't believe anyone since Darwin ever had a better support system than those of us lucky enough to participate. Here is wishing UIC-NARL the very best for now and in the future.

Sincerely,



Chas. E. Carson, Ph.D.
President, SCS

CEC:jz

IMPRESSIONS OF BARROW, ALASKA 1977-1978

In January of 1976, I received some rather interesting news. We were going to be in Barrow, Alaska. What an exciting prospect, since I had never been to Alaska. Gosh, living at the Top of the World, what more adventure could a person ask for?

My husband was to become the new Commanding Officer of the NARL (The Naval Arctic Research Lab). We moved from San Diego, California to Barrow in March of 1977. In the ensuing months I would come to appreciate the sun and surf of beautiful San Diego.

On a rather cold windy day (-70 F) in late March 1977, I arrived in Barrow, completely outfitted in my new Eddie Bauer down parka, snow pants, winter gloves and snow mask. The new terminal had not been built at this time, so the walk into the terminal was a frosty freezing introduction to the Arctic cold. However, the cold neither frosted nor froze my enthusiasm for the new life in the arctic.

Our house was built on pilings driven into the permafrost. I learned all about gray water, honey buckets, hauled water and arctic freezers. Arctic frontier living was certainly a challenge to this city person from California. Since I could not drive to the local mall (there was one in Fairbanks a few air miles away) catalogue shopping was the answer.

For some people Barrow was a form of purgatory, for me it was an interesting and different part of the world. I obtained employment at the local courthouse as the Assistant Magistrate for the North Slope Borough. My boss, Charlotte Brower was the Magistrate and needed the assistance.

On a daily basis I saw and sometimes participated in the lives of the people of Barrow. Sometimes the unpleasantness of criminal acts was overwhelming. It never failed to amaze me the acts of cruelty one human could inflict upon another human being. The better part of my job was performing four civil marriages; and registering births.

As a newcomer to the arctic I had a lot to learn. One day, on my solo excursion into the village, I decided to take a shortcut. Of course, I did not know the difference between snowmobile tracks and tire tracks of a car. I proceeded to bury the truck tires halfway up in mud. Fortunately a NARL truck came and pulled me out; needless to say, no more straying off the road for me.

One morning in late April of 1977, I was beginning to wonder if there were any birds in this strange part of the world, I heard the sound of a small bird singing loudly. What a wondrous sound, one lone bird perched on a fence post singing in the Arctic.

There are so many memories of living in camp; the noon whistle that would set off the howling of the wolves; the CAT trains leaving and returning during the summer; the constant roar of the airplanes and helicopters taking off to resupply the research camps on the ice islands. One vivid memory I have is strolling along the beach in June and marveling at the blueness of the water in contrast with the white of the ice flows.

More memories are of the constant stream of visitors and VIPs from the outside; and the winter, twenty-four hours of darkness with only the red-orange brim of the sun at high noon. For entertainment the Air Force shared their 1950's movies and we listened to Mayor Eben Hopson's weekly radio address. I especially recall the shrill of the whistle to warn of a polar bear in camp; the panic until you could find an open building for refuge.

Many of the scientists shared generously their time educating people about the arctic. Who could forget Dr. Kelley's excursions to the ice caves and Dr. Laursen's trips to the tundra to explore the valleys, forests and flowers of this miniature world.

My first experience eating muktuk was memorable. I was offered a piece by a well-meaning Eskimo friend. I had to excuse myself and find the ladies' room, as the thought of eating raw whale blubber was "too much to swallow." There were other parts of the Eskimo culture I found more intriguing such as skin sewing and colorful parkas.

September 1978, came too soon, it was time to leave the NARL and Barrow. I arrived in March 1977, with the enthusiasm of a novice and departed with an appreciation for a different kind of life and people. I had met many people: natives, scientists, educators, co-workers; many have become life-long friends.

On a September day I left Barrow, pondering a new life in a place called Washington, D.C. The Barrow experience had changed my life, some may call it an appreciation for the stark reality of the north. I prefer to remember it as the sound of the wind moving the snow across the ground in concert with the howling of the wolves...

Diana Thomas (Christian)
Barrow, Alaska
March 1977 to September 1978

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

COMMERCIAL FISHERIES MANAGEMENT
AND DEVELOPMENT DIVISION

TONY KNOWLES, GOVERNOR

P.O. BOX 25526
JUNEAU, ALASKA 99802-5526
PHONE: (907) 465-4210

May 27, 1997

To the Residents of Barrow and the North Slope Borough:

On this 50th anniversary of the Naval Arctic Research Laboratory (NARL), I would like to thank the people of the region, and in particular the residents of Barrow, the Ukpeagvik Iñupiat Corporation and the North Slope Borough for taking on the responsibility and making the commitment to ensure the continuation of the search for a better understanding of the Alaskan arctic; its resources and its people. As the person charged with the management of the state's subsistence, commercial, and personal use fisheries, I know the importance of and appreciate the need for good solid basic information about the resources one is responsible for, as well as an understanding of impacts one's actions might have not only on the resource, but the people who depend on those resources or have a close cultural tie to them as well. The research projects that have taken place at NARL have provided much of that good solid basic resource information. But equally as important is the interactions between those of us who have worked at the Lab and the local residents. They not only showed us the warm-hearted neighborliness of the people of the area, they imparted to us the importance of mankind's relationship with the other creatures with whom we share the arctic.

My first exposure to NARL, its staff and the people of Barrow, was in 1969 when I came off a U.S. Coast Guard icebreaker that had been conducting research in the Chukchi and Beaufort Seas. I found folks to be very friendly and helpful in getting crew and equipment off the vessel, out to the airport, and on our way home. I returned in the early seventies to participate in International Tundra Biome projects under Dr. Vera Alexander and conduct studies of sea ice algae under Dr. Rita Horner. During this period, I was fortunate to spend an entire year in Barrow. For one raised in Fairbanks, the dark and cold were no bother. Like many small Alaska communities, Barrow is friendly, open and sharing. In addition, it held the thrill of a new environment. For those who have never seen it, the first sunrise of winter and the contrast of ice and daylong sunlight in the summer are sites to behold.

Not only are all the people of Barrow to be thanked for their hospitality; those Barrow residents who worked at NARL are to be especially thanked for the assistance and guidance they gave to those of us who were performing the fieldwork. I especially remember Joeb Woods and our trip down the Colville River. Ken Toovak, who made sure that I had dependable transportation, but also took the time to make sure that I knew how to operate the rig safely and passed on that local knowledge so critical to getting out to a site and back. Pete Sovalik and Harry Brower, who assisted us in carrying out our tasks. There are many others, but quite frankly, age has taken its toll on my ability to remember names.

You are a proud people, as you deserve to be. Be proud of your accomplishments with the continuance of the work of the NARL. I for one am thankful that you have taken on this task and accomplished so much. My best wishes for the next 50 years.

With much thanks and appreciation,



Robert C. Clasby
Director

Lou DeGoes
 17215 Northern Sea Street
 Bellevue, Washington 98008
 206 640-0866

25 July 1997

Dr. John J. Kofsky
 Co-ordinator, Arctic
 Institute of Marine Science
 Univ. of Alaska, Fairbanks, AK 99775

Dear John,

By now you should have received the books, reports, photos, and other materials that I mailed to you last week. I will look to you to place them wherever they might serve Arctic research.

I very much regret that I shall be unable to participate in the celebration of the 50th Anniversary of the founding of the Naval Arctic Research Laboratory (NARL) at Barrow on Aug. 4-8; I'm scheduled for a cataract operation about that time.

I'm delighted that the old NARL is now the UIC-NARL facility and placed into the good hands of the Ukpiaqvik Iñupiat Corporation and the thrust for education and research thrives at Barrow. Congratulations to all those responsible and best wishes for a successful and enjoyable gathering.

In 1958, we (Air Force) established the Mt Chamberlin-Barter Island, Alaska research camp at Peters/Schrader Lakes. We were quite fortunate and thankful for the superb help we received from the NARL, especially from then-Director Dr. Max Brewer, Dr. Max Britton (ONR) and the many local members of the NARL staff. As you know, the name of the research station was later changed to "G. William Holmes Research Station, Lake Peters, Alaska" in memory of the late Dr. Holmes, the first Director of the research program and who was assigned to the AF Terrestrial Sciences Lab, under contract arrangement with the Military Geology Branch, USGS.

Initially, heavy airlift to establish the camp was provided by the Alaskan Air Command, Elmendorf AFB, Anchorage. Later, rumors were circulated that the Alaskan Air Command was planning to take over the research station and convert it into a Recreation Center for (fishing and hunting). Around 1960, Max Britton, Max Brewer and I arranged for a transfer of all Air Force Camp assets to the ONR-NARL thereby frustrating any Alaskan Air Command plans to desecrate this valuable and beautiful area.

Please pass my regards on to our good friends at the Barrow celebration.

Cheers,
 Lou DeGoes

25 July 1997

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Please pass my regards on to our good friends at the Barrow celebration.

Cheers,

Lou DeGoes”

EOI Research Associates

July 21, 1997

Richard Glenn
Conference Chairman
Barrow Arctic Science Consortium
PO Box 955
Barrow, Alaska 99723

Earth Ocean Sciences
200 Camino Aguajito, Ste. 202
Monterey, CA 93940
(408) 373-1576
Fax (408) 373-1578

Dear Mr. Glenn

Thank you for your invitation, I regrettably will not be able to attend the Celebration of the 50th Anniversary of the Founding of the Naval Arctic Research Laboratory.

I was the Science Director from 1973-1976, and during that period I depended heavily upon all of the employees of NARL. In fact, since the inception of NARL and before, the native people have played a crucial role in the success of many United States science expeditions into the Arctic. I came to NARL in a time of change. A change that was necessary for the conduct of the science program. It had to build on the knowledge and skills of the past and the Native People. However, the scientific endeavors required change, which I think many of the old hands found difficult. I think that this was the case because many of the People were struggling so hard to hold on to their cultural ways and values and instill them in a new generation. Anything that appeared as change threatened the way of life they were fighting so hard to preserve. I did understand their concerns.

There are so many experiences that I could share, that it is hard to choose. Some were wonderful some not so wonderful. There were many achievements during our time working together. It was the busiest period ever in the scientific program; we supported more scientists, had more people on the ice, flew more air support, etc. We were asked to do more with less, which we did, and we accomplished our tasks without serious injury. This was not my doing, but the achievement of the excellent staff of NARL.

I came to understand the contribution of the People of the north slope of Alaska when I first came to Pt. Barrow and ventured out to T3 (Fletcher's Ice island) in the mid 1960's. I gained my first real understanding of sea ice from Pete Sovalik and Kenny Toovak. Of course, I did have some "book learning" on the subject, however, books never captured the reality. I came to appreciate the "can do" attitude of the People when I worked on T3 and watched Charlie Hopson in his skimpy airforce jacket, jeans, and ear-band clearing snow from the runway for the airplanes to land. The temperature was very cold and the winds blew the snow back onto the runway almost as fast as Charlie could clear it. I remember that Charlie left the ice, only to return a few days later. Some of the rest of us were rather desperate to get our work done so we could go home. I asked Charlie why he was back so soon, and he commented that he was broke. I jokingly questioned what happened to his weeks of back pay, and he said he went to Fairbanks to get a hair cut. I am sure he had a good time.

The Barrow Arctic Science Consortium wants the laboratory to continue to function as a scientific center and maybe even return to its past days of utilization and productivity. I am sure that many changes have taken place at Pt. Barrow since I left. However, I want to leave you with this thought: If your laboratory is to fill its proper roll, it will have to have open doors to change. It is the very nature of science to be creative. Scientists may come to your laboratory to study the region, the People, or the past, but always with some vision of the future. If your laboratory is to fill its destiny, it must accommodate the change and provide the innovation needed by the scientific community.

Many of the scientists that have used NARL over the years will come to your celebration. I am sorry that I can not I am sure that you will have a fine gathering and I wish you future success with your laboratory.

Sincerely,



Warren W. Denner
President

WWD:pm



Nuwuk Site (at Point Barrow) as it appeared in 1952. Photo, J. J. Koranda.

THOUGHTS ON THE FIFTIETH ANNIVERSARY OF UIC-NARL FACILITY

The Ukpeagvik Iñupiat Corporation is to be congratulated most heartily for the noble job of maintaining - indeed resurrecting - the U.S. Navy's old Arctic Research Lab. at Pt. Barrow. It is still the farthest north lab in United States territory.

Over the years, so much important work was done out of Pt. Barrow - basic studies laying the ground work for our understanding of polar phenomena, and increasing the nation's ability to conduct field investigations under Arctic conditions.

My initiation into the problems of doing field research under winter conditions in the Arctic was in the winter of 1959-60, when I was sent north by Dr. Barnes, University of Washington, on a project to upgrade the quality of current measurements under sea ice. Dr. Barnes told me, "Go see what can be done with our existing instruments, and report back about what must be done to get greater validity to our current data." Upon arrival in Pt. Barrow, the first task was to adapt the gear to Arctic conditions. In doing so, we found one glaring problem in one of the current meters. This was in the days of mechanical meters, and I had a brand new one - a beautiful instrument, but the compass box fit just as well backwards as frontwards - sure to be a source of error in the field.

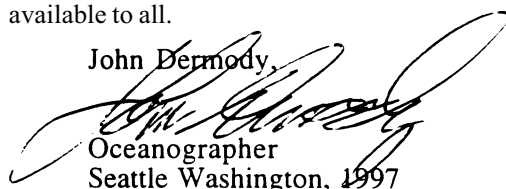
What to do? I took the instrument to the shop, where we had a brainstorming session - we being myself Kenny Toovak, Frank Akpik, and anyone else who happened by. The result was a rather ingenious little modification, which successfully "idiot-proofed" the meter. This mod was later published as an Instrumental Note in DEEP SEARESEARCH.

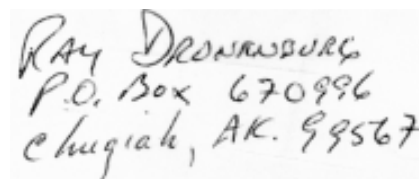
When all was ready, we began observations, flying out to our field points in the lab's two Cessnas. Bobby Fischer was senior pilot at that time. His later crash was such a tragedy. Bobby had a real knack in finding a piece of sea ice that was good for landing, and was next to a recently refrozen lead so we only had to dig through a foot or so of ice to get our instruments in the water.

We did this for a few days, learning all the while. Then it was time to try for 100 consecutive hours of current observations, this being the minimum amount of data required for harmonic analyses of the tidal component. The Laboratory Director at that time was the legendary Max Brewer, who had a fit when I asked him if I could keep the airplanes out on the ice for "about four days." He offered an alternative. "Here is a portable radio beacon," he said, confidently, "when you have your 100 hours of data, all you have to do is turn on this switch, and we will fly out to get you on the next flyable day. We can take you out there tomorrow." Being left out on moving sea ice, even if all I had to do was turn on a switch wasn't too attractive an idea, but the decision was made for me because at this point, my technician said, "I quit." We didn't want to be out there without transport, so I asked if the lab could get a dog team and driver to take us out and stay with us for the four days. This is how I met Phil Sovalik, who loaded our gear, and tents, food and fuel on his freight sledge pulled by nine dogs. We had to help the dogs over every little ridge, but we got to a good spot about 15 miles out, made camp and began observing around the clock, not getting much sleep, but lots of data. Phil stayed with us and four and one-half days later, we got back to Pt. Barrow with our 100 hours of data. I don't ever remember being so tired, before or since, but we had accomplished our job.

As a result of this work, modern current meters, using solid-state electronic technology were developed by industry which overcame many of the shortcoming reported by Arctic investigators.

To the people of Barrow, particularly the Ukpeagvik Iñupiat Corporation, many thanks for keeping the Arctic available to all.

John Dermody,

 Oceanographer
 Seattle Washington, 1997


 A handwritten note in cursive script on a light-colored background. The text reads: "RAY DRONENBURG", "P.O. Box 670996", and "Chugiak, AK. 99567".

RAY DRONENBURG
P.O. Box 670996
Chugiak, AK. 99567

The Barrow Arctic Science Consortium (BASC, Inc.) Barrow, Alaska

In recognition of the 50th anniversary of the founding of the Naval Arctic Research Laboratory

Sirs,

I was fortunate to have served at the Naval Arctic Research Laboratory from fall 1976 through summer 1980. I was originally hired as a Marine Operator, advanced to Marine Superintendent and served for a short time as Acting Director for Operations before funding shortages required closure of the laboratory in 1980.

In my capacities as Marine Superintendent and Director for Operations we attempted to work closely with the village school district. Through funding provided by CETA (Comprehensive Education and Training Act) I supervised high school applicants from several villages in various activities related to "marine awareness." For instance, with support of the Alaska Department of Fish and Game, we purchased a sonar/radar set. We then used this equipment to attempt to determine diving and swimming habits for migrating bowhead whales. Dr. Ira Dyer of the Massachusetts Institute of Technology was present in Barrow to see some of our experiments and invited our participation. With our equipment, on a summer cruise in and around Boston to attempt the same research with Fin Back and Hump Back Whales. Five high school seniors accompanied myself to Boston for this experience. On a separate occasion, funding was secured for students to travel to San Diego, California where we worked with Sea World. Students were actually placed in positions of "aids" at Sea World to determine interactions of sea mammals in captivity.

In the fall 1979, the Bureau of Land Management approached the Laboratory to assist with a project to determine, in various locations, the presence or absence of bowhead whales. This research required the setting up of various field camps and the use of NARL marine vessels. Wherever possible students from the North Slope Borough School District were invited to participate. Eventually this effort resulted in the present day research effort conducted by the Alaska Eskimo Whaling Commission to census whales passing Barrow. As Project Manager for the BLM project and Senior Scientist for the Whaling Commission effort we always relied upon local knowledge and participation.

I have many great memories for those days. I have pictures of myself and Robert Aikens - upriver hunting geese; I have pictures of myself and Kenney Tagaruk at the taking of his first whale where he recovered a tag that had been placed by a Russian Scientist several years earlier and which said "if found please return to Moscow." I have memories of myself and Marie Adams visiting senior whaling captains with the intent of recording whaling history and of my deck hands Ben and

Roy Nageak who are now great leaders for the community. I spent many hours playing pinochle with the “admiral” as he was affectionately referred to by Eugene Brower of his Father, and best of all, my son John was born in Barrow and so we are both a part of the history of NARL and Barrow.

I am every grateful for my memories for adventures - from the ice island T-3 to supporting a downed aircraft in Thule, Greenland. From “Jumper” pushing 55 gallon drums of fuel from the DC-3 to para-drop support to field camps to Dr. Sathy Naidu asking me to set a small current meter from the *Nachik* near Pingok Island. (The small current meter stood five feet tall and weighed in at 500 pounds and darn near tipped the boat over.) From the R/V *Alumiak* pushing its way through “burgie bits” to the R/V *Nachik* getting ice bound at Kaktovik. And I am grateful for the many friends that I see in various places throughout Alaska and who are part of the history.

My name is Ray Dronenburg and I am appreciative that I was part of this history.

□

G. Edgar Folk, Jr.
Department of Physiology and Biophysics
BSB 6-470
University of Iowa College of Medicine
Iowa City, Iowa 52242

April 1, 1997

Dear Residents of Barrow Village:

My wife Mary and I were privileged to work at the Naval Arctic Research Laboratory for many years doing experiments on the physiology of the animals living along the Arctic Ocean shore. The reason we came there was because of inspiration and information provided by Professor Larry Irving, Professor Donald Griffin, and Professor Alton K. Fisher. These individuals taught us of the rich opportunity for learning new biological information from the animals at Point Barrow. Mary and I were privileged to begin observations on arctic animals in 1961 and spent some part of every year there until 1977. Two of my students lived at the laboratory for two full years in order to collect information on arctic animals which they then molded into a Ph.D. thesis.

The significance of coming to NARL is that it was like attending a university: our teachers were Kenny Toovak, Pete Sovalik, Chester Lampe, and Harry Brower. We came to learn from them about the behavior of the arctic ice pack, and the behavior of the whales, bears, caribou, wolves, wolverines, ground squirrels, snow buntings, sand pipers, turnstones, phalaropes, owls, ducks, geese and swans. Why come to Point Barrow? There are interesting shorelines along the Pacific coast and the Atlantic Coast where we could have done work in biological research. Point Barrow however has a unique addition to the impact of the physical environment upon animals. That is the 82 days of continuous sun above the horizon and 82 days of continuous darkness in winter. We came to study the effects of these great environmental extremes upon all the animals that have been listed. We could not have done these studies without the conscientious contributions of our four "teachers" mentioned above and many of their friends and relatives.

I would like to end this letter of thanks by telling a little bit about the detailed contribution of Pete Sovalik. My research technique was to use physiological radios, which would broadcast body temperature, heart rate, and the EKG record of the heart. These had to be implanted in the abdominal cavity of the animals mentioned above. The transmitters were small and we never recorded the slightest harm to any animal asked to carry the transmitter in the abdominal cavity. We often made observations like this: two polar bears weighing 300 pounds each carrying a small radio in the abdominal cavity would chase each other in the pool then come out on land and wrestle and box and play violently together. There was never indication that their "style was cramped" by the small radios within their body. One of them, Irish, lived to be 22 years old in the Rhode Island Zoo, still carrying the same transmitter. Unfortunately at about age 15, his brother died of pneumonia, which had

nothing to do with the transmitter. How did Pete Sovalik come into the act: In the first place he brought the baby polar bears in from the ice. At that time Mary and I weighed them at 25 pounds and we weighed them throughout their lifetime. When Irish left for the Rhode Island Zoo we weighed him at 1000 pounds.

Concerning Pete Sovalik, because Mary did the anesthesia on these difficult animals while I did the surgery, the director of the laboratory insisted that one staff member be present in case the dangerous animal became active. Thereafter Mary and I had many pleasant hours with Pete Sovalik in attendance while we did our operations. It was our good fortune that Pete told us stories of relations between the Indians and the Inuit and many fables concerned with individual natives who became animals, or animals that became natives. Fortunately a student (Bruce Ehrenhaft) that we brought with us, stayed on to live at the laboratory semi-permanently; he recorded on tape many of these stories from Pete and they' have all been typed in final form.

At one time I came to talk to Pete and said; "Pete as I walked along the shore a flock of geese landed against the sun and I couldn't quite see what kind they were. Did you happen to notice them?" Pete said, "Did you hear them make a call?" I said "yes, but I can't reproduce it". So Pete said, "Was it one of these?" Then he proceeded to imitate the calls of at least four kinds of geese and asked me to pick out which one it was that I saw landing a few minutes before.

This is just one example of the fortunate rich experiences I was privileged to have over many years with the residents of Barrow Village.

With much affection;



G. Edgar Folk, Jr.
(Professor)

GEF/awc



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July 9, 1997

Mr. Benjamin Nageak, Mayor
North Slope Borough
P.O. Box 69
Barrow, Alaska 99723

Dear Ben:

I want to take this opportunity to congratulate the Barrow community and the North Slope Borough on the 50th Anniversary of the establishment of the NARL. Unfortunately, I will be unable to attend the celebration due to other commitments but I extend my sincere best wishes.

I first visited Barrow and the NARL in 1975 while employed with an environmental consulting company in Anchorage. While there I was impressed with the Animal Research Facility (ARF) and thought how great it would be to conduct research there, away from the hustle of Anchorage and consulting. About a year later I saw a notice that the ARF was looking to hire two post-doctoral fellows in late 1976. I applied and was successful in obtaining one of the positions. I started there in December 1976 and with a 1-year extension continued until January 1979. Those were 2 of the most interesting and profitable years of my professional life. The work was great; the animal colony was well populated with animals such as foxes, wolves and wolverines which were, and still are, of greatest interest to me; the facility was well equipped to conduct research in my area of expertise; and the climate was well suited for a bulky person like myself who dislikes temperatures much above 70F. My research focused on arctic fox thermoregulation with additional work on wolves and wolverines. Also, in collaboration with the Alaska Department of Fish and Game, Harry Reynolds specifically, I had the opportunity to conduct physiological monitoring of grizzly bears in the Utukok River drainage south of Barrow.

Having researched foxes since graduate school in Illinois, I had a long standing interest in rabies, a disease well known in the

Alaskan arctic. In 1977 I began a collaborative research project with the Alaska Division of Public Health in Fairbanks to assess the occurrence of rabies in the arctic fox population around Barrow. Harry Brower, Sr. then head of the NARL Carpenter Shop, was an avid fox trapper and was most helpful in getting fox carcasses to me after he skinned them out. He did this for several years, even after I had moved to Fairbanks in 1979. He enjoyed trapping very much and would run his trap line even during years when the fox population was very low. I once asked him his secret in being so successful in trapping, even when few foxes were around. After some persuasion he offered that a few drops of a certain Portuguese wine (Mateus) placed at the trap site was the secret. The twinkle in his eye when he told me made me somewhat suspicious about whether that was the real secret! At any rate, the project was successful due very much to the help provided by Harry Sr. He was most helpful on a variety of projects that were conducted through the ARF, most notably the bowhead whale project.

I will always remember the good years working in Barrow. My experience there allowed me to become more directly associated with the university in Fairbanks. In 1979 I moved to Fairbanks and held the position of Senior Research Associate at the Institute of Arctic Biology prior to obtaining a tenure track position jointly in the Institute and the Department of Biology and Wildlife in 1989. My association with the NARL was very instrumental in my being able to make this return to academia. I have maintained an interest in the North Slope having conducted several projects in the villages of Barrow, Kaktovik and Nuiqsut since my move to Fairbanks. I hope to continue this association into the future.

Again, my sincere best wishes for your celebration and for continued success in scientific investigations of benefit to the North Slope and its people.

Yours sincerely,



Erich H. Follmann
Professor of Zoology



Canadian Circumpolar Institute

1 April 1997

Mr. Benjamin Nageak, Mayor
North Slope Borough

Dear Mayor Nageak,

I am unable to be present on the occasion when you will celebrate both the 50th Anniversary of the former Naval Arctic Research Laboratory and its more recent rebirth as a vibrant community-based research and educational center, the UIC-NARL Facility.

As a student in the 1950s I was well aware of the excellent research being conducted at Barrow, much of it ground-breaking and full of excitement for arctic biologists. My own interest in arctic ecology was particularly drawn to the work of Frank Pitelka and his efforts to understand the causes of animal population fluctuations, especially lemming peaks and crashes, events that still seem to baffle biologists it seems.

I first visited Barrow in 1967, when I was part of the Canadian team that met at NARL with our U.S., Danish, and French colleagues to plan the International Biological Program (IBP) Human Adaptability Project Study of Eskimos as it was called. Among our Canadian group, were the late Don Foote (who had studied whaling at Point Hope and was involved in the studies that helped sink the highly dangerous Project Chariot at Cape Thompson). Don's tragic passing a few years later following a car accident, was a great loss to arctic studies, northern people, and his family and many friends. Also in that 1967 group was Tiger Burch, who is one of the great contemporary scholars of Inuit/Iñupiat society and whose work continues to inspire researchers.

During the days we were in Barrow for that particular 1967 workshop, I was able to meet a number of townspeople. I remember in particular Hank Panigeo, his wife, his brother, his niece (from Oakland, CA) and his elderly mother. I had wanted to take home, to Newfoundland where I was living at that time, some niqipiaq to share with my family; more especially I hoped to buy some caribou and maktak on sale at the store. But Hank insisted on giving me a good supply, and I remember his kindness to me, a stranger before we met, to this day.

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At that IBP workshop were others, well remembered I'm sure at Barrow. Robert (Bob) Spencer (of the University of Minnesota, who had written about coastal and inland groups of Inupiat), Bill Laughlin (then of Wisconsin, later Connecticut), and Richard (Rick) Nelson (who had just finished work at Wainwright as a student of Bill's). Later, I was to work with Bill and Dick (and others, including Wendy Arundale, John Bockstoce, and Rosita Worl) when I chaired a NOAA-IWC panel to help resolve the problems associated with the bowhead hunt in the late 1970s.

I have only made a couple of trips to Barrow since that time thirty years ago. In the 1980's I visited Barrow as a member of the Science Advisory Committee of the Northwest Territories, and John Kelley led us on a tour of the town and the UIC research facilities. I also visited Barrow in connection with a study I was involved with that looked at the AEWRC research and management plan. That particular trip took place at the end of the spring whaling season, when the whale census work was just ending due to the ice conditions. But I was able to visit the spotters' camp at the ice edge, and remain very grateful to Marie Adams, Tom Albert, Geoff Carroll, and Craig George for their several kindnesses during that trip. At that time, I recall you were Director of the Wildlife Management Department, and we did meet briefly during my visit.

So, as I look back on events that brought me into contact with NARL and the people of Barrow, I certainly have fond and quite vivid memories of those occasions. Over the years I have rekindled some of those memories by continuing contact with Barrow residents at meetings of IWC, ICC, bowhead conferences organized by the Borough, and various scientific or northern meetings. I look forward to continue these contacts well into the future.

I extend my best wishes to all those associated with the UIC-NARL Facility; may the facility prosper and may the work conducted there benefit the good people of Barrow and the rest of Alaska on a progressively increasing scale as the years go by.

With warm personal regards,



Milton M.R. Freeman
Senior Research Scholar

NORTH SLOPE BOROUGH

Department of Wildlife Management

P.O. Box 69
Barrow, Alaska 99723

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or: (907) 852-0350
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(907) 852-8948

Charles D. N. Brower, Director



Craig George
Wildlife Biologist
Department of Wildlife Biology
Barrow, AK 99723

Benjamin Nageak, Mayor
North Slope Borough
Box 69
Barrow, AK 99723

Dear Ben,

The following is a brief recollection of my early years at NARL where we met almost exactly 20 years ago. Time has gone by quickly which attests to the incredibly interesting journey we've been on—watching Barrow change from a remote Eskimo village to a modern city with a fascinating mix of traditional and contemporary ways, and raising our children together here.

As you know, I worked as an animal caretaker at the Animal Research Facility (ARF)/NARL for the University of Alaska from May 1977 to August 1978. I came to the Arctic directly from Jackson, Wyoming. The change from the Rocky Mountains of Wyoming to the flat coastal plain of Alaska was rather dramatic. I had some difficulty adjusting and figured I would not stay long. However, I had a strong 'support group' composed of a number of friends from the Jackson area. These included: Lane Franich, Jay Crenshaw, Mike "Soupy" Cambell, Mark Herrington, Todd Sharp, and Rob the Carpenter. They refurbished an abandoned hut (Hut #155) and offered me a room where I quickly move in. The real advantage of living in the 'hut' was the open interaction we had with the villagers since the Main Lab was closed in the evening. I quickly struck up a friendship with the regular visitors at the hut: you (Ben Nageak), Roy Nageak, Nate Elavgak (*Pamiuq*), Chris Stein, Charlie Brower, Price Brower, Frankie Akpik, Hubert Hopson, and others. Thus began a colorful, interesting, and often exciting (sometimes *too* exciting) experience which has continued for 20 years.

My job at NARL was to provide animal care for a rather impressive list of arctic mammals (and one snowy owl). During that time we held, at a minimum, the following animals:

Common Name	number
Wolf	25
Wolverine	3
Arctic fox	9
Red fox	3
Ermine	1
Least weasel	1
Brown lemming	25 +
Collared lemming	A few
Arctic ground squirrel	Ca 20
Arctic marmot	Ca 12
Ground hog	17
Polar bear "Irish"	1

Pat Reynolds was the director of the ARF in 1977 when I arrived. I knew Pat and her husband Harry Reynolds in Wyoming where they were involved in wildlife research. George Shelby became director in 1978 when Pat and Harry left for Fairbanks. I was trained by Jay Crenshaw, who was intern trained by the rather famous "Eskimo biologist" Pete Sovalik. I worked with several animal caretakers between 1977 and 1978; these were: Jay Crenshaw, Selena Brotherton, Tim White, John Smithhiseler (temporary), Otsuko Ohtake, Steve Oomittuk (temporary), Dan Coffey, Connie Carter, Beth Meininger, and Becky Gay. I still keep in touch with most of these people.

[The following is a brief update on these people: Becky Gay lives in Anchorage where she is executive director of the Resource Development Council; Connie Carter married Steve Oomittuk and lived, until recently, in Point Hope, they have three children: Beth Meininger moved back to Pennsylvania; her father owns the company which makes the darting and shoulder guns used by Alaskan Eskimos for bowhead whale hunting; John Smithhiseler worked for the Institute of Marine Science (UAF) for many years and now resides with his family in Anchorage, Jay Crenshaw is a biologist living in Idaho (?); Otsuko Ohtake went to medical school and became a doctor; Selena Brotherton lives in Fairbanks with her sled dogs.]

Working with the animals is always unpredictable; and working day in and day out with these critters was an unforgettable experience. I can say I am one of the few people to be bitten by a wolf. Old "Duke," an ex-alpha male wolf, grabbed me from behind while I was cleaning his cage. I shouted and swung around and he backed off. He had waited ten years for that moment.

Tom Albert was working on Arctic marmots and ground squirrels during that period. He was on sabbatical from the University of Maryland. Tom had his hands full with the veterinary care for his menagerie of animals, and with the research thrown in, worked himself to near exhaustion. In one study, Tom monitored the body temperature of the Arctic marmots (*M. browerii*) in an outside hibernaculum (which was built by Harry Brower, Sr.). Several times a week, he would stay up through the night recording data. One evening he walked out of the ARF office and headed for the animal quarters where his instruments were situated. I had left a ringed seal lying in front of the door, which I planned to feed to the captive polar bear. Unfortunately, the seal attracted a wild bear into the yard and as Tom rounded the corner practically walked

right into the bear. The bear took a swing at Tom as he ran back to the safety in another building.

Many people recall the baby marmot “Dugga” which Tom allowed to run free in his office. I would often see Dugga curled up in Tom’s lap as he worked.

Erich Follmann, now a professor at UAF, was working on an Arctic fox project during my time at the ARF. Erich had about nine foxes instrumented in a run between the ARF and Carpenter Shop. He was studying their activity in relation to temperature which he monitored via radio telemetry. The foxes were some of the most entertaining animals at the ARF and each had a distinct personality. For instance, the foxes seemed to have bottomless appetites. At feeding time they would carefully take each food item, disappear into their dens and snow caves and return until it was all gone. They would then reappear like mournful starving animals and I’d run back for extra food. In the spring I realized I’d been fooled when hundreds of chicken heads, chicken wings, fish and eggs appeared melted out of the snow banks—they had simply cached them and eaten surprisingly little.

Mike Philo was the resident veterinarian and was working on a rather ambitious Ph.D. project on water balance and energetics of wolves. Initially he had several wolves for which he would monitor all of what went ‘in’ and what went “out” of them. This required special cages which caught all the excretions. All of their food and water also had to be measured. To top it off, all of the work had to be done at ambient temperatures. Periodically, we had to move the wolves into squeeze cages and take blood from them without anesthetizing them! This was very delicate, interesting and high adrenaline procedure. The following year, Mike’s Ph.D. committee decided he wasn’t doing enough and required him to run the wolves on a tread mill (!) at ambient temperatures. I was not there for that aspect but heard it was a great challenge for Mike, the animal technicians, and the wolves.

Mark Chappel was our resident ‘genius’ and the time and was working on small mammal energetics—primarily of lemmings and weasels. [He had the first ‘personal computer’ that I had ever seen; \$2,500 bought him a crude homemade looking device with 8 K (?) of memory which only ran BASIC.] His research approach was interesting. He caught several animals and made metal casts of them with heating coils mounted in them. He then carefully sewed the skins back over the casting. The metal animals were placed in a home-fabricated wind tunnel (from two 55 gallon drums) that had a series of radiometers mounted on it. He then measured heat loss from the animals and at various wind speeds and temperatures.

Jack Lentfer, a polar bear biologist with the U.S. Fish and Wildlife Service, was a regular visitor in those days. John Smithhisler and I assisted him with attaching the first satellite collar ever fitted on a polar bear. He captured two females and we held them in our cages at the ARF. They were extremely aggressive and potentially dangerous. Jack darted one of the bears and began to attach the rather complex harness and collar to the bear. Unfortunately the bear awoke during this process and Jack and his assistant ran from the cage with the bear in pursuit. Luckily John stood back and when they cleared the cage door he simply pushed it shut before the bear to exit.

John Burns would appear occasionally at the ARF when he was collecting seals from a helicopter. John would shoot the seals from the air, swoop down hanging off the skids and gaff the seal before it sunk. This was a rather delicate and dangerous operation particularly in subzero weather. John then did the necropsies at the ARE with our eager assistance.

By far the most interesting animal was Irish the polar bear. After working with him for a few

months I realized I was dealing with a great intellect who *craved* stimulus in order to stay sane in his relatively small cage. His strength was incredible too. We played tug-o-war with him using three people on the rope. We would feed the rope into the cage and Irish would bite the line, pull it to his chest with one paw and begin backing up on three legs. In a straight pull, three fairly large men could not stop him. He pulled until we reached the cage and then he would lunge for us. His most impressive display of strength was his ability to pull a large truck tire through the 4" space between the cage bars. He would bite the edge of the tire with the canines on one side of his mouth, place both front paws against the cage and pull. The tire made an awful sound as it squeezed between the bars.

Irish had a bowling ball that he played with and rolled around in his cage. He could pick it up using his muzzle and one paw and in one instance balanced it on the 4 inch wide edge of his pool. He did the same with his hemp rope.

The best example of his intelligence was his figuring bow to open the gate between his two cages. Feeding required that we lure him to one side of the cage with a couple fish and then close the heavy vertically sliding steel door between them. Irish figured out that he could lift the door to open it and once he almost got one of the caretakers. So they fabricated a long steel rod which pinned the door shut by sliding horizontally through a hole drilled the door. Irish managed to slide the bar sideways to 'unlock' the door. By the time I arrived in 1977, we had to pad lock the bar in place when we cleaned the cage!

The wolverines were always entertaining. One of them, Murie, was always in a bad mood while the other two. Newton and Lotta actually were quite good-natured. We could hand feed both of them—although we probably shouldn't have. The challenge in working with them was bringing them in for examinations. They did not like to be restrained. Oddly enough, the wolves were trained to enter a carry cage (dubbed the "Tundra Taxi"). We could simply walk in the cage with a shovel or plywood 'shield' and they would dart right into the cage. We would then haul them into the ARF. This was not the case with the wolverines and it required drugging them with a jab stick or more often a dart pistol to bring them into the ARF. This was very hard on them and us. Smithhiseler and I developed a den box/capture cage to get around this problem. The system used a sliding door on their den box which we pulled shut with a long piece of parachute cord. The box also had an internal squeeze cage mechanism which allowed the veterinarians to easily and painlessly drug the animal with a hypodermic needle. We tested it on Lotta, the smallish female, and the system worked like a charm. Then we tried it on Newton, a large male. He trapped easily, but as we brought the box into the AEC, he managed to claw and bite his way through the 1/2 inch plywood in less than a minute (!). I was carrying the box and quickly ran back to the cage as his muzzle protruded through the plywood. We reinforced the door and, for the most part, the system worked well.

One of the things many people recall about NARL was the "five o'clock howl". At precisely 5 pm a siren would blow indicating the end of the work day. This set off all 25 wolves into an incredible chorus which would last 3 to 5 minutes.

Handling the wolves every day, it was inevitable that some would escape. In one case, two animals got out and blasted off through the NARL camp. Several of us took off armed with rakes and shovels, managed surround them in a wide circle around NARL and work them back into the ARF yard where they ran right into their cages. It seemed a miracle at the time but the wolves were probably very uncomfortable outside the cages where they had grown up.

Two people that really made the ARE run smoothly were Sally Manning and Debbie Eberhart. Sally in particular was a remarkably hard and organized worker. She also ran the blood diagnostic lab at the ARF.

I am leaving out many stories and many people in this account. The ARF was a one-of-a-kind research facility where many of the 'top' names in arctic biology had spent some time (e.g., Robert Rausch, Pete Sovalik, Laurence Irving, John Burns, Frank Pitelka, Ed Folk, Steve MacLean, Dave Norton, Bob White, S. Bee, Larry Underwood to name a few). I feel fortunate to have been associated with (and to continue to work at) this historic facility.

Finally, I would like to commemorate the recent loss of our mutual friend Lane Franich. Lane was a fine person and one of the most universally liked individuals I have ever known. In recent years, Lane was a tremendous help with the bowhead whale census. We will deeply and *truly* miss Lane.

Sincerely,

A handwritten signature in black ink that reads "Craig". The script is cursive and fluid, with the "C" being particularly large and stylized.

Craig George

July 14, 1997

This 50th anniversary celebration of the Naval Arctic Research Laboratory (NARL) stimulated me to reflect on my life at NARL, which began 33 years ago. I've looked over notes and letters that I had written during my time at NARL and I've abstracted some of that information here as a remembrance of the joys and frustrations I experienced during my pre-doctoral research study of the bioenergetics and thermoregulation of snowy owls.

I was a researcher at NARL as a graduate student in the 1960s and as an assistant professor in the 1970s during the following specific periods:

1965, June 22 to August 30;

1966, June 10 to August 21, September 14 to December 30;

1967, January 1 to 28; September 1 to December 22; and

1973, January 3 to 30.

I spent a total of 56 weeks at NARL over this period spanning about 8 years.

Summer 1965

My wife and I came to NARL this summer to collect data for Dr. Ed Folk. It was a lemming high year and the avian predators were abundant. In addition to our research activities for Dr. Folk, we collected 20+ snowy owls that summer to launch my Ph.D. research program on snowy owls.

July 7: Research has moved slowly up to date. A water truck drove into the power lines supplying our instrumentation building, breaking the wires and dropping a 220-volt line onto the line to our radio receivers and associated recording equipment. This caused a transformer to burn out; we expect a new one next week,

1966

This summer, my pregnant wife, remained in the lower 48, and an undergraduate student, Jim Parker, was my assistant on the snowy owl project. My son, Jeff, was born in late August. We brought him to NARL when he was 3-weeks old to spend his first Christmas and winter at Barrow.

June 11: I was quite upset upon arriving this summer at NARL to learn that only 7 snowy owls are still in captivity. I had expected that 20 owls would survive from last summer. Apparently many died from lack of a proper diet and a few were killed by more dominant owls. We are planning to look for owls at Cape Simpson, 50 miles east of here, and have called and sent letters to people in the NWT in an effort to locate populations of snowy owls.



June 15: The carpenters have started work on the aviary and should be finished tomorrow. They moved out all cages except the two bear cages and are raising the roof 4 feet.

June 17: Max is very cooperative this summer. He told me to bring my requests for cage construction and the like, directly to him, rather than first submitting a work request. A new surgery table, four owl cages and a supporting rack to keep the cages 2 feet off the ground were built.

June 19: Max is planning to install a one-way glass window in the aluminum building looking out over the sanctuary. An observation platform will be constructed next to the window which is located about 10 feet above the floor of the building.

June 20: The research is progressing slowly. Max hasn't set a date for the snowy owl searching trip to Cape Simpson.

June 23: Jim Parker and I worked hard all morning and afternoon on laying out a telemetry antenna in the aviary. Max has agreed to surround the animal sanctuary in copper screen in an attempt to shield from the static which has been playing havoc with our telemetry reception. As usual, Sunday dinner was good—candlelight and all, including chocolate covered cream puffs for dessert. Today was my best mail call so far—8 letters and 1 package.

July 1: I feel more sure about my research project after my talks with Larry Irving and George West from the Institute of Arctic Biology. I am making certain changes in the original plans and will be doing a few things that have greater chances of success. The big challenge is to find 10 or more snowy owls, including some adults.

July 9: The copper screening for the aviary, which was ordered from Seattle, hasn't arrived yet. Keeping the owls in separate cages for collecting feces didn't work out well, the weights of the owls never stabilized and they beat their wings against the cage sides opening wounds in their skin. I can substitute the feeding experiments with oxygen consumption measurements that I will do at the Institute of Arctic Biology.

July 15: Harvey flew Pete Sovalik and me to Oarlock Island at noon and picked us up at 5:30 PM. We set 11 traps on the island, each baited with a live ground squirrel. No luck; at least 3 owls were observed, but they didn't seem to be interested in the squirrels. Weather has been fine for 3 days and shorebirds are migrating in the thousands. Thousands of red phalaropes fed along the shore about half the distance between Barrow and the bridge. They flew in small groups over the road to the mud flats and back and forth. We collected about 400 dead or dying phalaropes on the ground, which had flown into the power lines, breaking their wings or worse.

July 16: I'm still waiting to speak with Max. I have been trying to talk with him for 2 days. I want to increase the size of the white rat colony, which is small, and to restate my desire to obtain a few gulls on which to practice implanting radio transmitters. He said last week that a few Eskimos would be sent out to trap gulls. I know that no one has been sent out yet, and so it goes.

July 17: The prospects of locating more snowy owls is not improving. Guy Shephard and John Kelly flew over the area where Kelly had seen white birds earlier this summer; they did not see any white birds. Max is seemingly less willing now to venture out in search of owls than he had led me to believe five weeks ago. He doesn't come right out and say that he is less interested, but strongly implies it by telling me how much it costs to operate an airplane for one hour. He is becoming famous for beating around the bush. I only wish he would say yes or no and stop leading me on. Two of the seven owls have fine plumage; the others are not fit specimens for a thermoregulation study.

July 21: Research is moving slowly. We don't have any birds to practice implanting radio-transmitters on. There is no word on the whereabouts of owls, the copper screening for the aviary

hasn't arrived yet, and because of the airline strike, Bill Ashlock, our invaluable telemetry supplier and technician, probably won't be able to visit Barrow as planned.

July 26: Max has said that he plans to send a Cessna with pontoons to Oarlock Island, where an owl was seen, and assess the potential of capturing the bird. Bill Ashlock did arrive and has done a lot to get the telemetry equipment in top form. He is planning to stay for another 1 ½ weeks. I am inviting George West to visit me about the time Bill is leaving. Hopefully a few adult owls will have been captured by then and the telemetry equipment will be in fine working order. The summer is hurrying along. I have feelings of deep self-analysis and reflection on my whole work toward a Ph.D., wondering if this is really what I want. The progress this summer has been much too slow for a number of reasons and it becomes increasingly difficult to convince myself that this is an efficient way to use my time and talents.

July 23: Max put me on a flight to Wood's Camp to search for snowy owls. We saw 6 owls and have mapped the locations. Max will send Pete and me to trap them when the floatplane returns from Kotzebue on Monday.

Aug. 5: George West and I were flown to Oarlock Island yesterday afternoon. We set out traps for the two owls on the island and tried to coax them to fly into the general area of the traps. We succeeded in getting one owl into the area of the traps, but did not capture it. Bill Ashlock will leave tomorrow night. The telemetry equipment has been modified in a few instances and is operating as well as can be expected for this equipment.

August 7: Progress on the project has been quite slow but it has not reached the point of failure. I am determined to see the project through unless it becomes definitely impossible, e.g., if all the captive owls die. We still have 7 owls; all seven have improved in plumage and health throughout this summer. It is almost impossible to make long-range plans, the project will be "played by ear."

Aug. 10: Max is still "putting me off." I haven't been in the field for snowy owl trapping since the short 2-hour episode 4 days ago. He says "probably" this Thursday. My distaste for the whole NARL operation is becoming disturbingly unhealthy. I am beginning to boil inside and a wrong comment from Max may be enough to push me too far and I'll tell him what I think of his so called "support" of my project.

Sept. 18: I now have 13 owls; six more than were here when I left NARL for a 3-week vacation in August. Max has not forgotten me.

Nov. 20: Wednesday morning we awoke to see the wind blowing snow at 40 mph into large picturesque drifts. The wind continued to blow hard for the remainder of the day. We were awakened at 4 am by the sound of a strong wind blowing over and down the heater vent pipe. We looked out the window and could hardly believe our eyes. The snow was blowing fiercely. It reminded one of a hurricane. By 10 am that morning the wind had subsided to 25-30 mph. The weather bureau in the village recorded gusts of 92 mph during the night - we weren't surprised at that figure.

Nov. 22: NARL carpenters made us a wooden box on runners to carry when Ann doesn't want to lug Jeff in the parka. We bundle Jeff up, put him in the box, which has a hinged top and vent holes, and pull the box along behind us. He generally falls asleep to the sound of the snow passing under the runners.

1967

September 13: The captive snowy owls are in excellent health this year. So far this fall I've devoted most of my time to a careful analysis of last year's research and to altering the

experimental design of my research on the basis of these findings and waiting for NARL to construct a few pieces of equipment that I need in the research, e.g., a wind-tunnel metabolism chamber.

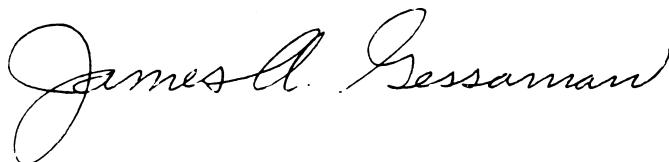
October 15: Construction of the new lab complex is progressing well. The walls and roof are up. The contractor is scheduled to finish all the exterior by Thanksgiving. The workers will leave for a 2-month vacation at that time and will return to work on the interior during the winter and spring. It should be a really nice research facility.

November 12: Jim went to Fairbanks on the Wien flight. We never know if Wien will be on time or several hours late, so Jim was waiting to pack his owls in cardboard boxes for the flight to Fairbanks. When he finally did hear he had only 15 min until the NARL taxi wanted him to be ready to go to the airport. It was about - 16 F and windy. We ran out to the aviary, put the 4 owls in their traveling boxes, and dashed back to the main lab. It was too cold to tie closed all the cardboard boxes in the aviary so we did that back at the lab. The last time Jim went to Fairbanks we were in about the same state. Jim had half a dozen things he hadn't gotten done that he was telling me as he left for the airport. I'm not sure I remembered them all. We now have 5 snowy owls in a walk-in freezer in the main lab. Every Tuesday and Friday the owls are weighed and the cages cleaned and all those materials processed. Jeff likes the owls and wants to "help" weigh the rats and feed the owls. He gets quite upset if we don't let him help.

The notes above provide a quick glimpse of the life of one pre-doctoral graduate student at NARL in the 1960s, and the overriding dependence of my research progress on the support of NARL administrators and staff NARL played an important role in my fledgling research career and provided a very valuable and memorable living experience at 71°N for 2 summers and parts of 2 winters. My training and experience at NARL was an important credential that led to my employment at Utah State University, where I have been for 29 years. On reflection, I am truly thankful for the opportunities that NARL provided me. Since I have been away from Barrow for 24 years, I am really looking forward to my return to Barrow for the 50th anniversary celebration of NARL in August.

My research at NARL resulted in the following publications:

- Gessaman, J.A. 1972. Bioenergetics of the Snowy Owl. *Arctic and Alpine Research* 4: 223-238.
 Gessaman, J.A. 1972. Design of a wind tunnel metabolism chamber for small animals. *J. Applied Physiol.* 33: 225.
 Gessaman, J.A. 1978. Body temperature and heart rate of the Snowy Owl (*Nyctea scandiaca*). *Condor* 80: 243-245.



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24363 Paragon Pl.
Golden CO 80401
July 10, 1997

Dr. John Kelley
Inst. Of Marine Science
Univ. Of Alaska
Fairbanks, AK 99708

Dear John:

I am pleased to contribute a letter on the occasion of the 50th anniversary of the Naval Arctic Research Laboratory, a first class installation that the U.S. Navy had established at Point Barrow, Alaska.

It was my privilege to be able to use the base, its support staff and logistics for my work on natural trace gases from the tundra (winter and summer) and from sea ice. I was there fairly regularly, sometimes for several months at a time, between about 1975 until its official closing in the early 80's.

Let me count the ways in which the Naval Arctic Research Laboratory assisted not only me, but all who were fortunate enough to have enjoyed its support for scientific research in the Arctic:

- 1) billeting was modern and kept clean and well maintained by the housekeeping staff
- 2) meals were always extraordinary, both in the dining hall and at remote camps.
- 3) the native crews ever helpful in the field and in handling vehicles, cutting scuba dive-holes in the ice—including a protective dive-hut,
- 4) the technical support that was always present when needed in the laboratory or for field support,
- 5) the ready availability of aircraft, single and multi-engine, marine vessels, and pilots and crews.

These were all that anyone could ask for in the remote and frequently hostile environment at high latitude. I know. First because of my considerable experience there, and second, because of the increased difficulty I found in trying to operate from the village after the base was closed.

Again Congratulation to the United States Navy, to former personnel and to the workers from the City of Point Barrow. on the occasion of the 50th anniversary of the Naval Arctic Research Laboratory.

Sincerely,



Thomas A. Gosink, Ph.D.
Univ. Of Alaska, Fairbanks (retired)



United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Circum-Pacific Map Project
U.S. Geological Survey, MS-901
345 Middlefield Road
Menlo Park, California, 94025

July 3, 1997

Dr. John J. Kelley
Arctic Institute of North America
University of Alaska
Fairbanks, Alaska, 99775-6808

Dear John,

Please extend my congratulations and best wishes to the Ukpeagvik Inupiat Corporation and the Barrow Community on the occasion of the 50th anniversary of NARL. The establishment of the laboratory at Barrow is indeed a landmark in the history of scientific research in the Arctic. Many organizations and individuals have had major roles in this 50-year history and they are well represented on the program. Not the least of these is the U.S. Geological Survey. In a recent letter to Richard Glenn (copy enclosed), I reviewed the history of USGS activities in northern Alaska. These early exploratory studies were the basis for defining the boundaries of Naval Petroleum Reserve No.4, and provided the geologic information for the U.S. Navy's oil exploration program, which led to the establishment of NARL. In response to the National Petroleum Reserves Production Act of 1996, the USGS was assigned the responsibility of continuing the U.S. Navy's oil exploration activities, up-grading and extending the Barrow Gas Fields to assure a supply of energy fuel to the Lab and local community, and cleaning up the debris left by past exploration activities. Thus when the U.S. Navy closed-out its support of NARL and no other support was evident, the USGS and its contractor, Husky Oil NPR Operations Inc., maintained the Lab and camp as the operation base to complete its assignment at Barrow and in the Reserve. All long-term, ongoing research projects at NARL were supported until 1982 when MC took over. The availability of gas at Barrow and from the nearby Walakpa Field, which was discovered near the end of the exploration program, has certainly contributed to continuing the Lab and to the expansion of the Barrow community.

I regret I am unable to attend the celebration and conference. In my recent letter to Richard Glenn I sketched my personal involvement in the USGS activities on the North Slope which began in 1944. Sig Wien flying, his famous Bellanca, landed me and Harold D. Roussopoulos on the Prince Creek gravel bar upstream from Umiat Mountain, the future site of the Umiat Camp. Thus began many pleasant and exciting years of geologic mapping on the North Slope and in the Brooks Range.

After NARL was established and Max Brewer became Director we were always supported and watched-over by the Lab and its staff. However our main operating base was Umiat and it wasn't until 1976, when the USGS took over the NPR exploration program, that I became a regular visitor to Barrow and became better acquainted with the local community.

In 1945, I and a party of 7 traversed the Chandler River from its origin at Chandler Lake to its confluence with the Colville River, probably the first to do so. Simon Paneak and the Nunamiut were encamped at Chandler Lake and so began a long friendship with that group including, in later years, at Anaktuvuk Pass. We had a wonderful time visiting with Simon and the rest of the village and I think we stimulated Simon's interest in science. I note and applaud the recognition of Simon in one of the talks scheduled for the celebration at Barrow. Our cook of the party, Charles Metzger, wrote up and published privately our summer's adventures in a book titled, *The Silent River*. I have enclosed a copy for the library. In 1990, in a letter to Ed Hall, I wrote about some of my contacts with Simon, copy enclosed. Ed was preparing a manuscript on Simon and his group but I don't think it was ever finished.. You are welcome to use it or excerpts from it in anyway you wish. There is much more to the story of USGS field parties and the building of the geologic information base for northern Alaska during the period 1994 to 1952 and this may stimulate my further writing. However there is a very useful summary in USGS Prof. Paper 301, by John C. Reed.

Again, I congratulate the Barrow community on the 50th anniversary celebration of NARL and on its development and support for the continuation of the Laboratory and for research in the Arctic.

Sincerely Yours,

A handwritten signature in cursive script that reads "George Gryc".

George Gryc
Scientist Emeritus
U.S. Geological Survey



HANSON ENVIRONMENTAL RESEARCH SERVICES

1902 Yew Street Road
Bellingham, WA 98226
Phone/Fax (360) 676-4497

10 April 1997

Barrow Arctic Science Consortium
P.O. Box 577
Barrow, AK 99723

Dear Sirs/Mesdames:

Although I have previously submitted my questionnaire and extended abstract of a proposed talk to be presented at your 50th anniversary celebration of NARL, I take this opportunity to send heartiest congratulations to you and the Barrow community on the occasion. Although I will be unable to attend, it in no way diminishes my great appreciation for the opportunities, both personal and professional, that having based out of NARL for some 22 years afforded me.

My involvement with NARL began in 1959 with the radiation ecology studies at Cape Thompson (Project Chariot), broadened in 1960-1980 as we learned more about the phenomena of worldwide fallout in the lichen-caribou/reindeer-carnivore (including man) food webs of northern Alaska, and terminated with the fading of interest in such studies by the sponsoring agency and the people of Anaktuvuk Pass. It was a good run, as the saying goes, and contributed an outstanding amount of knowledge to our understanding of arctic and subarctic ecosystems.

During the conduct of our studies we initially used a 5-ton whole-body counter, which we transported around the region from Kotzebue to Point Hope to Barrow to Fort Yukon to Arctic Village and to Anaktuvuk Pass, which was always the linchpin of our studies of worldwide fallout in arctic food webs. As we developed the technology of whole-body counting we were able to measure cesium-137 in humans with a 30-pound instrument, which gave us much more mobility and access to more remote villages with longer airstrips. This permitted our use of the NARL small aircraft (Cessna-180s) instead of the R4D, and we expanded the study to include the villages of Arctic Village and Ambler for

comparison of those peoples' food webs and resulting radiation exposure due to worldwide fallout. That capability completed our study of the residents of all major villages north of the Arctic Circle, with the exception of Kaktovik; however, we measured radioactivity of people of that village and several others (such as Little Diomedes, Kivalina, and villages along the Kobuk and Noatak Rivers when we had installed the large whole-body counter in a central location, such as Kotzebue, Point Hope, and Fort Yukon.

In summary, NARL and its very capable personnel led by Max Brewer and John Schindler enabled us to accomplish our studies in unparalleled fashion. When we reported our results at Scandinavian symposia there was great admiration for the considerable logistics involved in our studies and the breadth of our investigations that were possible. At one point we even proposed mounting the large whole-body counter in a large, twin-rotor helicopter and flying it to remote Canadian Inuit villages to expand our studies across the North American Arctic; however, we were dissuaded by diplomatic aspects and by then we had also developed the 30-pound instrument, which allowed the Canadians to conduct their own studies of northern peoples. NARL had no such large helicopters at the time, and I'm sure that Max, John, and the NARL pilots heaved a sigh of relief when we semi-permanently located a 5-ton instrument in a sod *ivru*luk at Anaktuvuk Pass in January 1964 to calibrate the 30-pound instrument for subsequent use in broader studies. The 300 27-pound lead bricks needed for shielding the counter made a deceptively-small pile, and I recall George English, C-46 pilot of a Wien Airlines charter to move us from Anaktuvuk Pass to Arctic Village in the summer of 1962, looking at half the load spread over the floor of the aircraft, deciding that he could handle a few more bricks, and subsequently clipping the upper few feet from the tops of willows at the lower end of the Anaktuvuk Pass airstrip on takeoff. He arrived for the remainder quite shaken, and made two trips with smaller bites.

Visiting the many villages of northern Alaska and their residents was a distinct personal privilege for me, in addition to accomplishing the scientific objectives of our studies. The

people were initially very indulgent in their cooperation, aided by the great assistance of Amos Lane of Point Hope. Amos traveled to the various villages with us during the entire summer of 1962, serving as translator and interpreter of the radiation readings for the people; it was important that the residents understood our objectives of explaining the meaning of worldwide fallout to circumpolar populations as well as the scientific aspects. Amos was invaluable in that endeavor, and his presence was a great asset as well; he had a seemingly endless number of "cousins" who came to the counter to investigate lineage.

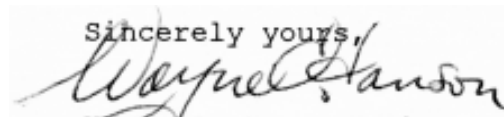
Pete and Isa Sovalik (and their son Max) accompanied us to Anaktuvuk Pass on our first whole-body counting episode there, and were most helpful in getting us off to a good start. They camped alongside the wanigan that John Beck's crew had just finished erecting for our use over the years and which served as a base for several other NARL-supported studies. Our arrival at the Pass was a big event, and we had previously cleared our studies with the Indian Health Service and explained our intentions to the Anaktuvuk Pass Village Council. Simon Paneak was Council President at the time, and we established a friendship that I treasured for the rest of his life. Homer Mekiana, Jesse Ahgook, Inualurak Hugo, and Elijah Kakinya were village elders at the time, and their warm welcome and cooperation in our studies was very gratifying. Their descendants have continued the camaraderie established by my continual (and sometimes aggravating) presence over the years to measure ^{137}Cs body burdens some 45 times during critical times of seasonal patterns. That was one of the most rewarding aspects of our studies. I counted every resident of Anaktuvuk Pass as my friend over the 18 years that I conducted studies there and I reminisce about those halcyon days with the *Nunamiut* in their beautiful Brooks Range homeland. We had cordial relations with many of the residents of the other villages where we conducted our studies, but nothing compared with Anaktuvuk Pass.

Covering the 120,000 square miles of our study area to describe the radioecology of worldwide fallout from nuclear weapons fallout in arctic ecosystems of northern Alaska required the

considerable talents of NARL aircraft pilots, and over the years we tried the patience and forbearance of many of them. Especially memorable are Dick Dickerson and Cliff Alderfer in the R4D hauling our counting gear around the North Slope; Lloyd ("Air America") Zimmerman; Jonathan ("Crash") Bowles; Guy Shephard and his 'Off-course Computer;' Joe Felder; Bobby Fischer; and Jim Aitkens.

The NARL staff in Barrow provided good company and unlimited support of our studies, and I am deeply grateful for their friendship and assistance; we couldn't have done it without them. Quyanakpuk!

Again, my thanks for your consideration and congratulations on the 50th anniversary of NARL.

Sincerely yours,

Wayne C. Hanson, Ph.D.
Senior Ecologist (ESA)

**WALKER LAKE COLVILLE VILLAGE
VIA 930 9th AVE.
FAIRBANKS, AK 99701**

June 12 1997

Dr. John J. Kelley
The Arctic Institute of North America
Rasmuson Library
Po Box 756808
Fairbanks, Alaska 99775

Dear John:

On the 50th anniversary of the Naval Arctic Research Laboratory [NARL] at Barrow I wish to send my congratulations and best wishes on a half century of research programs.

In the beginning no one was sure what direction the project would take and like Topsy it simply “grewed”. I well recall my first meeting with the program. There were ships unloading at the Point ferrying gear ashore. I had come in from the Eastern Arctic along the North coast in a 28 foot whale boat to pick up supplies at Charlie Brower’s store. The program’s aim was to search for oil in the PET 4 area and elsewhere in northern Alaska, and to drill exploratory oil wells. Supplies came by ship in late summer and by air from Fairbanks via Umiat. In winter they were hauled by cat train to the well site.

They had to develop their own ways and means in dealing with the Arctic. There were no regulations or guidelines and in this they were fortunate for they could dream and break new trails while learning new ways. The greatest obstacle they had to overcome was the vast mass of misinformation they already “knew” and had to unlearn before real understanding and learning could begin. It still is our greatest obstacle to understanding our entire Arctic. They found unlearning much harder than learning. Dr. Vilhjalmur Stefansson in his book *The Standardization of Error* published in 1927 began the task of, I suppose the best way to describe it, unlearning the many erroneous ideas about the Arctic. Even today there remains a vast amount to unlearn in the myths about the Arctic before real understanding can take place.

Dr. Vilhjalmur Stefansson was the first really scientific Arctic explorer and it was from his book *The Friendly Arctic* published in 1921 that the real nature of our Arctic land and the people was accurately and honestly described. Luckily the NARL picked up on the real truth about the Arctic and they fitted their program to match the land. They were also blessed with an abundant wealth of information from the indigenous people many of whom had supported and helped the early explorers while men like Tom Brower and Al Hopson had actually been part of one of Dr. Stefansson’s expeditions. It was a highly intelligent and cooperative people who helped in the founding of the NARL. It is so fitting that the local people through the UKPEAGVIK INUPIAT CORPORATION (UIC-NARL) now will carry on the work.

There have been many dedicated people who have served there over the past half century right from the start. There were people like Tom Brower, Sadie Neakok, Les Suvlu, Forrest Solomon, Sig Wien to name but a few at Barrow, for in reality all helped. Then men like Dr. Stefansson, Sir Hubert Wilkins, and Ben Eielson to name but three who were behind the Navy’s original concept, and Stefansson’s book *Arctic Manual* was really a textbook for the new programs. I did much of the flying along the coast or ice pack and I was in and out of Barrow. I helped all I could over the years from our home and research site on the Colville river delta. I had worked closely with Dr. Stefansson on some programs like the founding of the Arctic Institute of North America and he was a good friend and a help tome. He proposed me to The Explorers Club just 50 years ago.

Then there were men like Dr. Max Brewer who really set the NARL research program on course. He took hold and directed the program. Pilots like Bobby Fischer and Joe Felder carried out much of the flying. The Ice

Island Project was carried out later. The Russian drift station at the North Pole started in 1937. In Arctic exploration The Explorers Club played a most vital role and Max Brewer was elected to the Explorers Club because of his work at the NARL. Several of the people who worked at the NARL were Explorers Club members.

In looking back across those fifty years the NARL has played an important part in the furtherance of Arctic development. I see a wonderful mosaic of a great land, a dynamic population and a new effort to understand.

The NARL's original purpose was to search for oil in the Naval Petroleum Reserve 4 and all across the north of Alaska. This was carried out through the Arctic Contractors and at a really modest cost by today's standards. They were the first to explore and delineate America's greatest oil field, but they never did discover the great Prudhoe Bay strike. They found a few gas wells and a little oil, but it remained for private industry to find America's largest oil field. Their search for oil was an innovative one and they did develop many new concepts. I recall each well they drilled and their use of cat trains that were like freight trains moving across the frozen prairie.

They also add much to Arctic air freight systems. The steel mat runway on the pea gravel beach was the first such landing area in the Arctic. I recall what a welcome sight it often was, and I recall one special night when a C46 load of 55-gallon drums of gasoline had broken loose to end up in the far back. I was flying navigator and we were just barely flying tail way low when we landed with full power and a wild bounce. Aside from being badly scared, nothing was hurt. I will ever be grateful for that lighted runway that cold and dark winter night. The FAA inspectors were there inspecting Bobby Fischer's crash.

Over the many years our family provided fish from our Colville Delta fishery for the NARL animal research as well as we helped the many other fields of research. The NARL has grown from its search for oil to the larger program of understanding our remarkable North and of full cooperation of all of the people. It is up to all of us now to carry on their work of understanding and cooperation that Dr. Vilhjalmur Stefansson began almost ninety years ago so well recorded in his book, *The Friendly Arctic*. The people who live here are in reality one people in tune with our land. The Barrow Arctic Science Consortium and the North Slope Borough have a vital role to play in scientific programs and economic viability of our Arctic's future.

It is plain in looking back across the past half century of my association with the NARL that it would take many volumes, in fact half a library, to describe and explain that era. As you began turning the pages of memory, the many people most all of them gone now, come back just as real as they used to be. Their knowledge was like large libraries that have since burned down. To me so many are the old Natives who called it the friendly Arctic and home. They were George and Nannie Woods [Kisik and Weinyuk] to begin with a few of that long parade of dignified people that eventually included everyone there or who passed that way. I see also the many dreams and hopes of us all and the thousands of successful flights that were carried news, people, goods and of people helping people.

On the happy 50th anniversary of the NARL we want to extend our heartfelt thanks for the opportunity of sharing in the research of our great Arctic land. It is good to have been a small part of the NARL in the past half century, to have raised our children and grandchildren here at our research house in the Colville River Delta, to help find the Prudhoe Bay oil field and especially, like that long line of people before us, to call this fascinating land home. May good things come your way.

Sincerely yours,

Bud and Martha Helmericks



Colville River home.



Martha, Bud and Katie at Fairbanks home

ROBERT E. HENSHAW, PHD

91 Louis Drive, West Sand Lake, NY 12196

Telephone and Fax: 518-283-0415

PROFESSIONAL SKILLS FOR PUBLIC ORGANIZATIONS

Remembrances

10 July 1997

The years of 1966 through 1975 were the high point of my life. Coming to NARL each summer and each winter were important to me in two ways— both equally important: the unique opportunity to do hands-on research with large Arctic mammals, and the opportunity to learn from and about the Iñupiat.

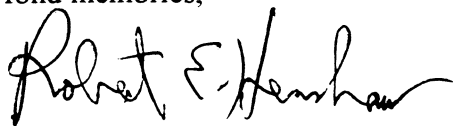
My research dealt with how animals protect their extremities from freezing. I found what the Iñupiat knew all along: that they must maintain an adequate flow of warm blood to their exposed parts. I also demonstrated that the arctic fox, which evolved in the Arctic, and the adult wolf, which evolved in the temperate zone, do not waste precious body heat. They maintain their feet at about 1°C, which is just above the tissue freezing point. The wolverine, with its thinner air coat and ornery disposition wasted more heat to survive in the cold and grew thick hair pads on its feet in the winter. Such work as others' and mine was virtually impossible anywhere else. Most studies of large mammals had to be binocular ecology.

I cherished the opportunity to know the Iñupiat. I spent many many hours learning ecology, biogeography, behavior, and physiology of arctic species from Pete Sovalik. Pete's first-hand knowledge was accorded the same weight in professional literature as scientifically derived information— a distinction none of the rest of us ever could hope to achieve.

NARL provided the unique research animal colony and the accessibility to Iñupiat staff with unique knowledge. These benefits can never be matched in institutions farther south, no matter how learned or how well supported. The biological work done by many researchers at NARL in the 1960s and 1970s will stand as unique contributions. Other researchers elsewhere will have to approach such research questions incrementally and will not have the multifaceted benefits provided by NARL.

The anecdotes surrounding these opportunities are too numerous to tell here. Better simply to acknowledge the significance of the opportunities with great gratitude to all who made them possible.

With fond memories,

A handwritten signature in black ink, reading "Robert E. Henshaw". The signature is fluid and cursive, with the first name "Robert" being more prominent and the last name "Henshaw" following in a similar style.

Robert E. Henshaw, PhD

CHARLES L. HOAR
30650 NE. BELL ROAD
SHERWOOD. OREGON 97140-8571
603-825-6056

10 April 1997

John J. Kelley, Ph.D., Coordinator
The Arctic Institute of North America
Rasmuson Library
Post Office Box 756808
University Of Alaska
Fairbanks. Alaska 99775-6808

Dear John:

Enclosed find my essay on my experiences in the "frozen north" at NARL. It was rather enjoyable sitting here reminiscing about our experiences with all of the people we met and associated with while there. Unfortunately, I couldn't remember all of the names of some of those with whom I had experiences, and those came mostly from the other contractor, and of course the Navy. And I do believe, I really didn't want to remember that experience at all.

Retirement has been doing me good. I still am involved in the Elks, but my time there is limited, since I have a major "caretaking" problem here at home. I believe I told you some time back that Shirley had been diagnosed as having Ovarian Cancer, which had metastasized throughout her system.

She had been holding up fairly well until last December, and then it all seemed to collapse, and now is under the care of Hospice here at the house. I still have all the daily stuff, but once a week they come and do what has to be done to alleviate her pain problems. She has lost huge amounts of weight and has no energy at all, but still manages to putter around the house and boss me around, which is good. It keeps me on my toes, and gives her something of interest other than knitting, books and TV.

That's about the extent of my doings, other than yard work, which never seems to get anywhere close to being complete. I wonder why?

Our best regards to Eleanor, and keep well, and thanks for the opportunity to put my two bits in the Anniversary Tome.

Sincerely,

A handwritten signature in cursive script, appearing to read "Charlie", written in dark ink.

Charles L. Hoar

Enclosures

CHARLES L. HOAR
 30660 N.E. BELL ROAD
 SHERWOOD, OREGON 97140-8571
 603-625-6056

10 April. 1997

The Barrow Arctic Science Consortium, Inc. Barrow, Alaska 99723

Gentlemen:

A surprise announcement arrived in my mailbox a couple of weeks ago, of the formation of your Corporation, and your intentions to celebrate the 50th Anniversary of the NARL. I hope you will accept my heartiest Congratulations in accomplishing a continuing effort to keep that marvelous facility vibrant and functioning. When I last left the NARL I had visions of it being closed down and left to rot as so many of the other top grade facilities of the Government have done in the not too distant past.

Since I was a participant in some of the activities at NARL, Doctor John J. Kelley wrote to tell me about your formation and about the anticipated celebration for the Anniversary.

Perhaps some recollection of memories will explain how I became acquainted with NARL and why Dr. Kelley wrote me about the Anniversary.

Most of my work in the Arctic was centered at Wainwright starting in 1971, when I became the Project Engineer for a Project created under the then new "Clean Water Act" which contained a provision for the design, construction and installation of a facility in Native Villages in Alaska to treat local water sources to become Potable, and then to dispose of the Human and solid wastes generated in the Villages. It was called the "Alaska Village Demonstration Project" (AVDP), and I was designated to provide all of the requirements to complete such a Project in Wainwright. In order to facilitate comings and goings into the Arctic, and knowing how undependable the weather was at most times, the Supervision Agency of the Government the Environmental Protection Administration, through their Fairbanks Office, made arrangements for me to utilize the NARL as a "stop-over" base for myself and some of my staff when we got "grounded" by weather in Barrow. Early on in the Project we were "bunked" at the Public Health Facility (the Hospital) until it became a problem for them, and the NARL agreed to accommodate us. Late in 1973, the facility at Wainwright was destroyed by fire. The EPA decided it should be replaced, and Congress, through the efforts of Senator Ted Stevens provided the funds for replacement. The new facility became operational late in 1977, and before the year was over, some operational and structural difficulties were encountered which required some intensive studies and investigation to determine what must be done to alleviate the problems. The Administrator of the original contract for the AVDP, Merritt Mitchell, contacted me at my office in Portland and made arrangements with my employer to prepare the paperwork necessary to do the studies and provide a Scope of Work to correct the difficulties found in the facility. These were accomplished during 1979, and then facility was transferred to the North Slope Borough for ongoing operation. It was during this period of time that I was a frequent visitor at the NARL.

During my early stays there. I was much too involved with my Project in Wainwright to recognize all of the activities going on around me at the NARL. But after a while, as I got to know a few of the people, it began to feel more like a home away from home, and I was accepted by the staff as another Arctic "character". The time I spent there was most rewarding because I got to know and appreciate these folks and what they were doing in the various

fields of Science in the Arctic. Dr. John Kelley, Dr. Gary Laursen, Lloyd Zimmerman, John "Jumper" Bitters, the LeCloirecs, Susan Hoffman, Dave Smith, and any number of others that have faded from my memory, and my address books.

During all of this activity in Wainwright I was fortunate enough to meet some wonderful people in Barrow. The first people of Barrow that I met were two gentlemen to whom I shall be eternally indebted, Joe Upicksoun, and Irving Igitanloc. They introduced me to the ways of people in and around the North Slope, and how to relate to the mores and traditions of the people of the North. Shortly after that I met Larry Dineen, then Eugene Brower, then I was fortunate to meet the greatest leader the people ever had in Barrow, Mayor Eben Hopson. There were numbers of others, but the folks I really had opportunity to know were Dick and Dolly Hedderman, who were involved in the schools at Wainwright before moving up to the Borough Administration. Again, there are many others that I became acquainted with, but as I have not been in contact with those folks, they have also faded from memory.

Shortly after I finished the Wainwright "rebuild" Project I received a call from Doctor Kelley asking if it might be possible for me to come to Barrow and the NARL to prepare a Proposal for the Navy to provide the steps necessary for the Navy to bring the NARL to a "Standby" Status, with the ultimate end being "Closure." An estimated Cost was put together by the firm for whom I was an employee, and I traveled back to the North to Prepare the A Proposal For Reduction Of Facility to 'Caretaker' Status. Before we through getting the original document finished, we were faced with some new directions from a new Commanding Officer, and this required a second Proposal, which encompassed additional data over and beyond what was originally envisioned. About the time the First Proposal was finished into Presentation form, and the second Proposal "Rough" Draft finished, an additional Directive from Washington arrived wanting another Proposal done incorporating additional facets which were not included in the original and the second Proposals. Of course all of them had to be ready for Presentation in Washington about two weeks after the third change came in. Between overnight Express shipments and a lot of luck Doctor Kelley and I reached Washington, DC, the day before the Presentation was to be made. After a rather trying conference, the Review Board decided to look into the Proposals in more detail and then the decisions would come down. About a week later, we were informed that none of these Proposals would be used, and they would continue operating the NARL for an additional year, as it had been that Fiscal year.

Needless to say, we were all disappointed at this decision, and we returned to our own environments wondering what the outcome of NARL would be.

It wasn't long in finding out Soon after I returned to Portland, I received a call from Doctor Kelley with a request that I get a sabbatical from my firm so that I could come to the NARL and relieve John Nolan as Contracts Officer. John had been offered another position in Washington near his home town, and it was an offer too good to refuse. The proposal was made to the President of my firm, and with workloads smaller than usual, he agreed that it might be a worthwhile project for me to undertake.

And so, I came to the NARL as Contracts Officer in the employ of the University of Alaska, reporting to Doctor Kelley. The main task that I was given was to prepare a plan to pack up and remove the University of Alaska from the Scientific Management of the NARL and to get it completed before 1 October 1980. Little did I know about the extent of the involvement of the University in the NARL, but I soon found out. The amount of data that had accumulated over the years was tremendous. But by indexing everything, and packaging it for loading into Wien Airlines "Cocoons," it became a daily routine of progress.

Just shortly after I became Contracts Officer, Doctor Kelley had to attend a very important meeting out of State, and needed to have someone fill in for him as Administrator during his absence. I discovered to my surprise one morning by a Memo laying on my desk declaring that

the Contracts Officer would be Acting Administrator during Doctor Kelley's absence. This responsibility became mine just two weeks after I had come aboard in my new job. With good indoctrination by the good Doctor, I felt that I wouldn't have any problems of any concern while he was gone. Wrong.

I don't think that the good Doctor was in Seattle before an unusual happening occurred. Our resident Airplane Driver, Lloyd Zimmerman was airborne with a client to do some aerial surveys of the shore of the Beaufort Sea somewhere near Icy Cape. Their ETA back at NARL was just before the evening meal. But during the dinner that evening note was made that Lloyd and the client had not yet returned to base. It was decided that radio contact should be made as soon as possible by the FAA Center in Barrow. No contact could be made. The Borough "Search and Rescue" was notified, and an aerial search was instituted. It wasn't until the early hours of the next morning that Lloyd's plane was found on the beach near icy Cape. Both he and the client were uninjured, and wondering why it took so long for them to be found. When the Search plane flew over them, radio contact was made, and it was then determined that where he had landed was in a "Zone of silence" for any radio contact with Barrow, and the western frequencies known to Lloyd were not responding either.

What had happened? During the flight Lloyd and the client both sighted what appeared to be a beached whale just East of Icy Cape. Lloyd surveyed the beach from the air and decided that it looked to be in a good condition for a landing. He did so, and on the roll out hit a soft spot in the beach sand and the plane nosed up into the sand bending the propeller. No other damage was found, and without being able to make radio contact they just waited to be found. The Search plane returned to Barrow, a propeller was then lifted by helicopter to Lloyd, and within a couple of hours he was able to take off and return to the NARL none the worse for wear. Quite an interesting two days for the neophyte "Administrator."

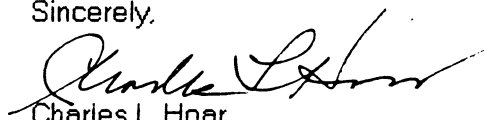
Nothing else unusual occurred after that exercise. I continued to get all of the University's materials loaded into "cocoons," made arrangements for shipment to Fairbanks, saw to it that all members of the staff were adequately relocated with all of their possessions, and with Doctor Kelley finished the loading of the cocoons" and transferring them to Wien's freight center in Barrow on September 28th. After a final inspection by the Doctor and myself accompanied by the Commanding Officer, we turned over all related paperwork etc. to the CO, and made ready to depart to Fairbanks to help sort out all that had been shipped there.

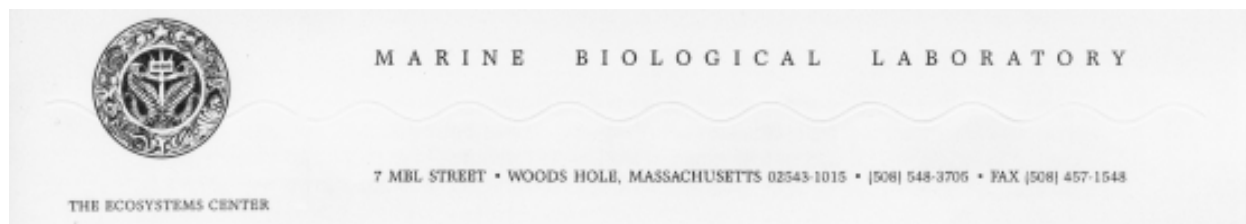
I remained in Fairbanks for another few weeks getting all of the materials identified, and all the paperwork straightened out and then left for a return to another exciting Project in Portland with my regular employer.

About the only thing I missed in Portland while I was the Contracts Officer at NARL was a little explosion just North of the City of Portland. I seemed that there was a volcanic eruption of a little mountain called Saint Helen; and the occurrence really rattled everyone's cage; but being at NARL all I saw was a few video pictures of a lot of smoke and steam, and it wasn't until I was on the flight home and flying over that mountain before landing in Portland that the immensity of that explosion struck home.

In reality, I really felt that the experience at NARL was much more closely felt than the Saint Helen's occurrence. Unfortunately, I have not had opportunity to revisit the NARL Barrow and Wainwright much to my chagrin.

Sincerely,


Charles L. Hoar
(Now Retired)



30 July 1997

Mr. Ben Nageak
 Mayor, Barrow
 Mr. Richard Glenn
 President, Barrow Arctic Science Consortium

Dear Mr. Nageak and Mr. Glenn:

I am very pleased to contribute this remembrance letter to the celebration of the 50th anniversary of NARL. All of us who have known the NARL for many years take it for granted and probably need to be reminded that it is a unique laboratory for the U.S. and for the world. When it was set up with ONR funding, it supported research on the arctic environment and arctic biota. The range of projects supported was wide and ranged from microbes to meteorology. The U.S. never had a similar laboratory for other regions such as the desert or tropics. One of its best features throughout the years has been that the NARL in all its forms has served as a meeting place for scientists carrying out a diversity of studies. All of us have been broadened in our scientific outlook as a result of the opportunities we had to work at NARL. I have kept up to date about how the village, the borough, and the BASC are continuing to foster science at Barrow. Congratulations.

I have spent several years at Barrow and at Lake Peters in the Brooks Range where the NARL had a field camp. My field studies there began in 1958. Two years later, my wife Olivann and I spent an entire year there. Although Lake Peters was a long way from Barrow, the NARL built several buildings there and supported us with Cessna flights every two week or so.

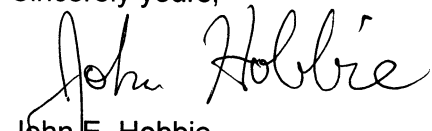
In June 1958 a Wien Airlines C-46 that was landing on the ice of Lake Peters punched its wheels through the soft ice. Two mechanics from Wien first floated the plane with empty oil drums and then spent the summer working on the engines. One of these was Rex Avakana from Barrow. Early in the fall the plane took off from wet tundra.

While I was at Lake Peters, Harry Brower came out and stayed for several weeks while he constructed a small laboratory building. There were many Dall sheep in the Lake Peters valley and I remember Harry and Lloyd Spetzman, a botanist, jumping out of the NARL plane, grabbing their rifles, and shooting four yearling sheep all in about two minutes. Pete Sovalik later told me that he spent a winter living on sheep only a few miles from Lake Peters.

During the winter of 1960-61 my wife and I came out from Lake Peters and spent a month around Christmas at Barrow - the NARL administrators could not understand how we survived without two more people to play bridge with! One vivid memory I have was that it was very cold in the valley at Lake Peters, so cold that the kerosene stoves all went out every time the temperature fell below about - 55 ° F. It doesn't get that cold in Barrow so the NARL people had set us up with an external kerosene tank with a quarter-inch copper feed line. The fuel oil jelled in the cold. Also, the neoprene diaphragm in the rocker pump I had out there broke in the cold — Max Brewer told me I just didn't know how to pump oil and that he wasn't going to keep sending new pumps out to an incompetent graduate student. One of our small generators did break, was repaired and was waiting in the carpenter shop at Barrow to be sent back to Lake Peters. Of course the next day the shop burned down so we never did get that generator.

I look forward to next week when I will see Barrow again and meet old friends.

Sincerely yours,



John E. Hobbie
Co-Director

□

Fairbanks, Alaska
May 28, 1997

John J. Kelley
AINA at UAF
P.O. Box 756808
Fairbanks, Ak. 99775-6808

Dear John:

In reference to your letter of March 23, 1997 regarding the 50th Anniversary of the former Naval Arctic Research Laboratory (NARL).

Directing my thoughts to those many years ago, this is what I have recalled:

I first went North from Fairbanks to Point Barrow on May 15th, 1947 aboard a Wien Airlines DC-3, N 21769 flown by pilots, Bob Rice and Bill Smith. There was no stewardess aboard.

We went to a Camp which was operated by Puget Sound and Drake, a company out of Seattle, Washington. There we had lunch in the Mess Hall, where I met Sandy Kallio, a Wien pilot who flew Sig Wien's favorite airplane, a big Bellanca 'Sky Rocket' N 14700. Sandy was a former Spitfire - pilot for the RCAF in WWII. I also met Judge Bart Gillespie the reknowned Judge of the North slope. Back at the airport I met Bill Laws, a mechanic for Wien Airlines, and two Eskimo natives, Forrest Soloman, and Joe Panigeo who also worked for Wien Airlines.

We then flew to Umiat, which was to be my home base for the next four months. I flew a J-3 Cub with 80 horsepower engine and prop, for the USGS. The first person I met there was Jim Dalton, a really fine fellow. Later during this period of time, I met Kathleen (Mike) Dalton when Jim brought his bride to live with him at Umiat. Ralph Steiner and his wife were at Umiat also, but I can't recall what his position was at that time. (The Steiners later lost their lives in the Pioneer Hotel fire in Fairbanks).

Others that I had met were: George Gates, George Gryc, and one other fellow whose name escapes me now, were from USGS Headquarters based in Palo Alto, California, and were in charge of the Geology Program. One other, Marvin Mangus, a Geologist who later directed Atlantic Richfield to the area where they were to spud in for their Discovery Well.

Other Geologists were: Ed Weber, B. Thurrell, John Reed, Dean Myers, Commander Greeman, Dr. Schwartz, and others whose first names I can't recall: Stefanson, Sorem, Spanner, Ruby, Patton, Detterman, -

Whittington, and Legge. Oh, I must not forget Jerry Koonz, the finest cook on the North Slope. Most of the old timers will mention his name in any conversation about Umiat.

Then there was Elder Liebert, the "Camp Cook" for the USGS parties out of Umiat. The geologists would make remarks about the Camp Cook earning \$600.00 a month while they were only being paid \$400.00 a month. I guess the stature of importance depends on the situation.

Also there, was Bert Galbraith, a very meticulous pilot who wore clean cotton white gloves all the time. Galbraith Lake was named for him by the geologist, after he and a Bird Scientist [*Rodgers Hamilton*] disappeared. They took off from Umiat to fly to Barter Island and were never heard from again!

Employed by Wien Airlines at Wainwright, and at Point Barrow were: Nimrod Bodfish, Sam Hopson, and Ned Nusunginya. (All fine fellows!) I must not forget Dave Brower, who was instrumental in much of the Activities of the North Slope and 'Pet 4' Projects.

That Summer I flew all over the North Slope for the USGS Geologists and we hauled back many pounds of rock samples to Umiat.

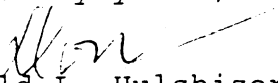
On September 13th, Sig Wien told me that our contract had ended, and I was to pick up a lady at Chandler Lake and fly her to Bettles, then fly the airplane back to Fairbanks. At Chandler Lake the wind was blowing something fierce and there was white caps on the water. After about a three-bounce landing I managed to get the plane to shore. The people gathered around to help hold the airplane. They were the nomadic Eskimo tribe from Anaktuvuk. I met their chief, Simon Paneak, Elija Kakinia and others. I poured in five gallons of gas the best I could with the wind blowing like it was. The Eskimo lady and two small children managed to squeeze into the rear seat, and then we made about a three-bounce takeoff from the lake and flew to Bettles.

Later that winter, at Anaktuvik, I was privileged to stay in Elija Kakinia's skin hut and shared a meal of fired Caribou!

All in all it was a very enjoyable Summer on the North slope, except for my memory of the torrent and torment of our terrible mosquitos!

Sincerely yours,

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Donald L. Hulshizer



May 10, 1997

To all those people who have been connected with NARL over the past 50 years I send congratulations.

My husband, James D. Hume, and I spent six summers working at NARL. He was a sedimentary geologist for thirty years at Tufts University. He first went to Barrow in 1959 as an assistant to Marshall Schalk who was working for the Navy studying the offshore sand bars, which plagued the landing crafts when supplies were shipped to Barrow. Jim, Marshall and I drove up to Fairbanks from Massachusetts and flew to Barrow. Married quarters were not available for us at the Lab, but we were able to rent an apartment in the Postmaster's house in the town of Barrow. I felt that this turn of events was to our advantage. We had a lot more opportunities to get to know the Eskimos than most people did. We rode the man-haul to the Lab with the laughing, cheerful Eskimos and took part in the town's activities. I was on the beach when a whale was brought in and butchered. I joined the town Women's Club and I learned to conserve water, cook ptarmigan and caribou and how to use dental floss to sew with. Eloise Okakok made parkas for us over the years. Her husband, Bert, ran Brower's store in Barrow. We kept in touch with them until they died

My present avocation started in Barrow. When the church played canned music on Sunday mornings, we used to take walks on the beach south of the town. I began to collect Eskimo artifacts that were eroding out of the cliffs at the old village site of Utkiavik. I am now a certified avocational archaeologist in New Hampshire. One of the scientists who was working on his Ph.D. at the Lab in 1968 and 1969 was Dennis Stanford. He taught me how to wash, label and catalogue the artifacts that I continued to collect at Nuwuk and Utkiavik. Dennis now works for the Smithsonian Institution and is a prominent figure in studying the Peopling of the Americas. We both attended a meeting in Maine in 1990 that focused on that subject. I have used the artifacts to give talks about the Eskimos and their tools to school children and adults since the early 1960s.

We spent a total of six summers working at the Lab (NARL) from 1959 through the summer of 1969. Jim continued Marshall's work and did several projects under his own contracts. He took Tufts University students to assist him as well as me. I worked in the dory and in the Laboratory. He mapped the shoreline from south of Barrow village to the area beyond the point; he studied the phenomenon of floating sands; and he studied seasonal changes in Elson Lagoon. Following a major storm in 1963, the Navy asked him to re-map the area because the shoreline changed so drastically. The spit was breached between the duck camp and the Point. The eastern side of the Point was eroded and the western side gained land.

I have many fond memories of Barrow, the Eskimos and all the people who worked at NARL. We kept in touch with a lot of them over the years but several have now died, including Jim and Marshall. I guess I am writing this for all them. We had

hoped to return to Barrow in 1979 to do a ten-year re-mapping project to find out how much change there was in that span of time but the Lab was closed due to lack of funding. There were a few Eskimos that stand out in my mind as special friends. Pete Sovalik took care of the animal house, assisted Jim on occasion, and helped in identifying artifacts. Joe Ahgeak assisted Jim with the boat. Kenny Toovak and Chester [Lampe] also worked at the Lab and I have already mentioned the Okakoks. I still keep in touch with the Schindlers and hear news about the Brewers now and then. I have kept in touch with John Kelley and would like him to know that I still have the lemming rug that he made for me back in 1959. I wrote articles for the "Point Barrow Life and Times" paper which was printed at the Lab, on collecting artifacts and the changes in life at Barrow over a ten-year time period. I painted water color pictures of the arctic flowers and beat a lot of men at ping pong. My kids will always remember Pete feeding the animals and thought the animals were their personal zoo. They also loved the planes on the dead line and now my son, John, flies his own plane. One thing that sticks in my mind was watching and taking movies of a whale being butchered on the beach at Barrow. Jim was away when this occurred so he was very surprised when he saw the movies I took because I was standing next to the guts rolling around on the ground and the whole scene was very graphic. The older people were all sitting around watching the process and it was all very much a scene of the Arctic.

Our Years at Barrow and NARL will always stand out as very special in my mind. Jim and Marshall felt the same way. I could write a book on it.

Happy 50 years!

Cheers,

Patricia W. Hume

Pat Hume

26 May 1997

Director
UIC-NARL
Barrow, AK

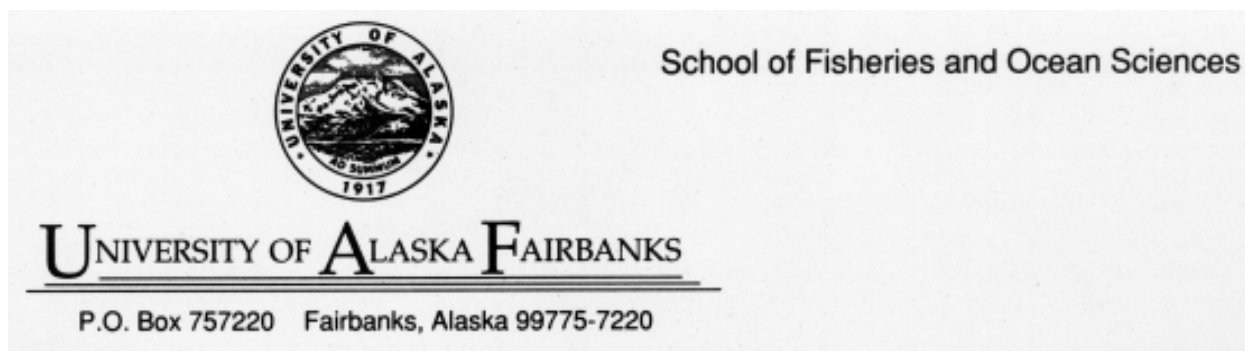
Dear Sir:

Congratulations on the 50th anniversary of the establishment of the Naval Arctic Research Laboratory. I was at the lab from 1960-63 and operated the geomagnetic observatory. The U.S. Coast and Geodetic Survey was my employer at the time. Max Brewer was the director and John Schindler his assistant. During those years it was my fortune to meet many extraordinary scientists and learn of their research projects; this period of time was a highlight of my long career. I will state, very briefly, some recollections that immediately come to mind. It is still a thrill to recall the whaling stories of Thomas Brower, of harpooning the huge mammals from a small skin-boat. Pete Sovalik was also an able storyteller of his various adventures in the arctic. Riley Sikvayugak and Chester Lampe did double duty at the lab by providing haircuts during the lunch hour. The traditional softball game between the camp and the village was a summer bit of sandy fun. And how could I forget that the "experimental" flush toilet was installed on the floor directly above my office! Additional words concerning that project are unnecessary. Being a small part of the 50 year history of NARL is an interval that will always be a great remembrance, a memory which I hold dear. What a learning experience—those three and one half years! Regretfully, all of scientists, personalities, and events cannot be properly mentioned at this writing. Once again my sincerest congratulations.

Respectfully,



Willis (Jake) Jacobs



August 1997

To the Citizens of Barrow, Alaska, via Mayor Benjamin Nageak, North Slope Borough, and Richard Glenn, President of Barrow Arctic Science Consortium

JOHN KELLEY'S REMEMBRANCES: THIRTY-SEVEN YEARS OF ASSOCIATION WITH THE NARL

My first contact with the Arctic and the ARL began somewhat problematically. A letter in 1959 from Admiral Charles Thomas (USCG, Ret) at the Department of Meteorology, University of Washington, inviting me to participate in "Project Husky" was a dream come true. At that time I wanted to pursue a graduate degree in some aspect of geochemistry and had corresponded with Dr. Charles Keeling at the Scripps Institution of Oceanography about studying the dynamics of carbon dioxide in the atmosphere and the ocean. I was very much drawn to the Polar Regions, although I had no experience. Admiral Thomas thought that this was a good idea but needed someone to go to Barrow to relieve Mike Miyake, a graduate student, and to set up the micrometeorology station at Eluitkak Pass on a lonely spit at Plover Point several miles from the Arctic Research Laboratory.

I arrived at the University of Washington on a rainy day in September 1959 and was on my way to Barrow a week later, but not without incident. I arrived at McChord Air Force Base in Tacoma for the trip North on a chartered Alaska Airlines plane. Travel orders were required. Admiral Thomas, being a man who liked to cut through red tape and get things done, decided that I should travel on orders which he had for himself but could not use due to other commitments. When I appeared at the MAC terminal desk as a young man in his 20s with travel orders belonging to an Admiral, this was surely a case for the Provost Marshal. Contact with the Admiral seemed to clear the air, however, and I traveled as an "Admiral" from Seattle to Elmendorf AFB and then to Fairbanks as the lowly simulated military rank that I was. I stayed at Murphy Hall on Ladd AFB, a SAC base at that time, and spent a delightful evening with Col. and Mrs. Quashnock of the Aeromedical Lab. I saw my first aurora. The next day I traveled to Barrow as the only passenger on a Wien Airlines C-46 aircraft, which was a very memorable experience. The stewardess was one Eleanor Johnson, who became my wife some years later, but that's another story.

September 29 was a dreary day at the DEWline terminal at Barrow when we landed. I was met by Mike Miyake in one of the ARL big wheel WW2 surplus trucks and whisked to the lab. There I met the director, Max Brewer, and was given greetings and advice before being sent on to the supply room to be fitted with appropriate clothing from the inventory of military surplus, some of it going back possibly to WW1. I was, however, comfortable.

My first day on the job included a trip to the “Point” with Mike and a load of equipment. It was a bone-jarring experience remembered even today. Mike told me of his being knocked out during one trip—a fanciful story, perhaps. The next day I was on my own, and my first encounter was with Otto Geist, who was conducting paleontology research through the ARL. It turned out that Otto desired to ship a large number of whale bones and other critter parts to his lab at the university. He usually was short of funds for this sort of thing, but that didn’t matter. After breakfast he saw me enter the lab and immediately motioned in his usual diplomatic manner, “You, come here. We must take these specimens to the airplane now.” I dutifully assisted in taking the smelly lot to a chartered aircraft at the hangar. Once the aromatic goods were loaded, an irate pilot showed up and had a rather long discourse with Otto about no more freebies, especially the foul smelling cargo that he so often put on board.

Despite his Prussian manner, Otto became a dear friend. He would sit in my lab in an old blue upholstered chair and smoke 1886 cigars and tell wonderful tales of his many experiences. I was introduced to “moosemilk” by Otto. I didn’t like it.

There are many Otto Geist tales. One that impressed me the most was Otto’s concern about Project Chariot. He felt uneasy about the Atomic Energy Commission plan to set off nuclear devices near Cape Thompson as part of Project Plowshare. He wrote many letters to the Congressional delegation and others, and I was enlisted to spend my evenings as his typist, tempered with cigars and whatever alcoholic beverage was available.

Otto was a collector. He would travel with me to the Point in the “weasel”. We took the “short-cut” four miles over Elson Lagoon. The lab constructed a cab on the weasel with a hatch in the roof in case the vehicle went through the ice. Otto would sit on the roof with his rifle to search for wildlife of interest. He would convey his steering directions by kicking me. It worked quite well.

The three months that I agreed to spend on Project Husky extended to almost three years. The ONR agreed to support my study of atmospheric carbon dioxide, and the first continuous measurements by infrared analysis were made there. It was a very productive time, and the lab assisted in establishing an ozone-monitoring network from Adak, Wales and Barrow.

What I remember most was the collegiality afforded by the ARL. It was truly a multidisciplinary setting with much cross-fertilization of ideas. The informal and unstructured setting, especially the morning and afternoon coffee breaks, afforded an opportunity for us to share experiences especially with the Barrow residents who worked at the lab.

I joined the Institute of Marine Science, University of Alaska, in 1969, in the same year that Eleanor Johnson decided to return to Alaska to complete her degree. We had kept in touch throughout the years and in 1970 decided to marry. The NARL was a natural choice for us because of past associations, so on a cold December day we traveled to Barrow to be married by Fr. Frank Mueller in St. Patrick's Quonset hut church. We were honored to have the Brewers (Max and Marylou) and Schindlers (John and Erna) as wedding attendants at the ceremony, followed by a very joyous reception at the lab.

I especially remember Pete Sovalik, who accompanied me in the skiff when I was making oceanographic observations. A lot of pleasant conversation took place on those trips. Ken Toovak was also a source of good advice on how to stay out of trouble. The Arctic may be friendly according to Stefansson, but not to the foolhardy and reckless. Ken's patience and steady hand was much appreciated. I enjoyed also the many hours of conversation with Harry Brower, who was a fountain of knowledge about this land of ice and snow. I was especially fond of Frank Akpik, whose spirit in times of adversity was unshakable. The fondest memories are from the *Natchik* cruise to Nome in 1962. We intended to leave earlier in the season, but mechanical problems delayed us. Frank and Wyman Panigeo piloted the *Natchik*. It was extremely rough in the Chukchi Sea, and we were greatly relieved to enter the lagoon at Point Hope. The *Natchik* had a few problems. One of them was lack of heat. Frank would sit in the Captain's Seat and say, "Max, my feet are cold." We eventually got to Nome via Diomed Island and put the vessel up for the winter. Max sent the R4D piloted by Lloyd Zimmerman to retrieve us. I left shortly after that to continue my graduate studies, but continued to visit the lab during holidays and in the summer to administer my projects.

No tales about the ARL are complete unless they contain "JB stories." JB was the lab mascot. He was a little elongated black dog of uncertain breed but well endowed. He spent most of his time in the director's office and greeted all who came to the ARL according to some protocol known only to him. He did recognize dog lovers and immediately took advantage of me and my roommate, Karl Stone. Like all dogs, he liked to nap. A favorite place for JB was under the hot water pipes around the walls of the lab. His coat was often hot to the touch, but this didn't seem to bother JB. His other favorite napping place was our beds. He, of course, enjoyed the pillow and was quite indignant when invited to get back on the floor.

JB imagined himself a terror of the tundra. His favorite sport on outings was lemming hunting. He was quite adept at this. However, digestion was another matter. On one occasion, my roommate was Professor Frank Pitelka. Frank was reading in bed when I came in with JB. Frank was a very friendly man and greeted JB with something on the order of "JB, to what do I owe this honor?" JB's response was an immediate upchuck of his day's catch of lemmings. Frank, of course, took this in good spirit. JB was eventually buried under the new laboratory.

Aviation played an important part in my research. The lab hired a series of skilled pilots and had an excellent safety record. I particularly remember Bobby Fisher, Lloyd Zimmerman, Ed Murphy,

Dick Dickerson, Guy Shepherd, Buster Points and Bob Main. I brought Lloyd Zimmerman back as Chief Pilot during the last years of the USN/NARL.

I spent the years 1974 to 1980 at the National Science Foundation and as the last director of the NARL. I knew that my task would be to transition the lab to a new host or close it. During those years we conducted a substantial amount of new research which led to acoustic stock assessment of bowhead whales and numerous studies through the animal research facility supported by Dr. Art Callahan at ONR. No new federal or nonfederal host could be found, and the lab eventually transitioned to the Ukpiaqvik Iñupiat Corporation as the UIC-NARL managed currently by the Barrow Arctic Science Consortium (BASC). I believe that the timing was right for such a transfer to the community. The Navy's interest in the Arctic was minimal, especially in the Beaufort-Chukchi Sea. The lab had to have latitude to fully utilize its land and resources for the benefit of all, not just a small group of scientists. It seems to have taken almost a decade to transfer the real property to the community, but fifty years from the founding of the lab it is still in existence and has every indication of growth.

During my years as director of the NARL, I had the pleasure of working with Eben Hopson, the first mayor of the North Slope Borough. Later, as chairman of the North Slope Borough Science Advisory Committee, I had the pleasure of working with subsequent mayors Jake Adams, Eugene Brower, George Ahmaogak, Jeslie Kaleak and Ben Nageak. I must acknowledge the great support and friendship I enjoyed throughout those years of Dr. Tom Albert, who initially came to Barrow as a visiting scientist at the NARL and returned as senior scientist in the borough's Department of Wildlife Management.

The fiftieth anniversary of the NARL has brought back a lot of nostalgia as I have proceeded to collect numerous letters from former investigators as part of an Arctic Institute of North America project to put together a book of remembrances.

The consensus of opinion is that the laboratory was a focal point for research and an intellectual crossroads for the exchange of ideas concerned with arctic science and engineering. The location of the lab close to the community of Barrow has been very beneficial both to the investigators and to the citizens to share experiences. The ARL of years past and the UIC-NARL today are important national assets. I'm grateful to have shared some part of its first fifty years, and I salute the Next Fifty!

Seiti Kinoshita



↑ Otto Geist next to a stranded piece of multiyear ice near Point Barrow - March 1961



"J.B." The lab dog... Also an Archie Hero...

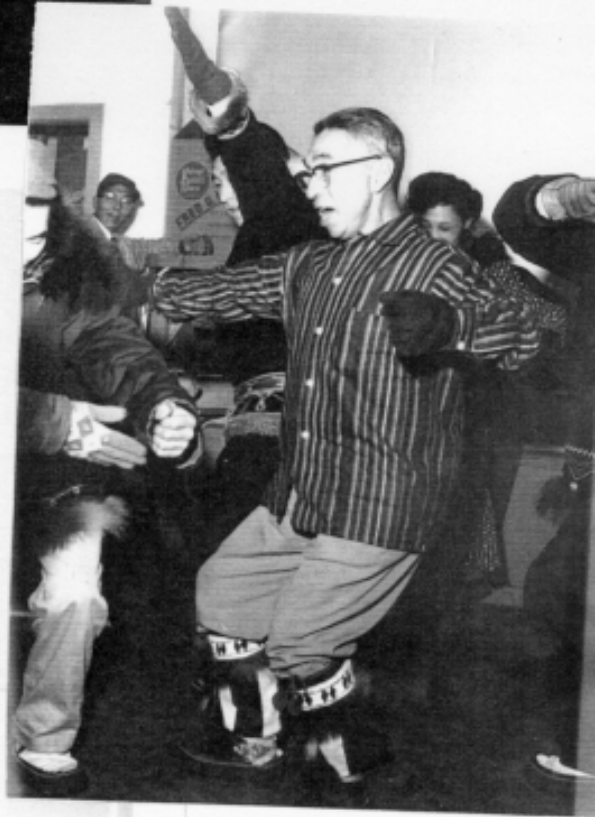


← Otto Geist frequently visited my lab at the ARC. March 1961



*Eskimo Dances
1960*

*Pete Soualik and
Chester Lampe*



*← Pete Soualik and
"JB" during coffee
break at the AEL
1960*





R. Bergstrom, A. Ibañez, J. Kelley and W. Jacobs aboard the *North Star* off Barrow village, 1960.



Carbon-14 productivity studies. Carbon dioxide monitoring station on beach, 1960.



Who says you can't get a weasel stuck? Coming off the bluff at Barrow, 1969. C. Benson, J. Kelley, G. Weller.



RV *Natchik* being launched for a cruise to Nome, August 1962.



Air sampling at Pt Clarence. Air samples were collected *en route* to Nome for analysis of carbon dioxide.

The Okhotsk Sea Ice Museum
of Hokkaido at Mombetsu send
greetings to the Naval Arctic
Research Laboratory on the occasion
of its 50th anniversary.

They recognize with admiration
the great contribution to arctic
science which this organization
has made, and they send their best
wishes for continued success.

Director.

Okhotsk Sea Ice Museum

Seiiti Kinosita

Seiiti Kinosita

16 June 1997



Tom Cade and young rough-legged hawk in the mid-1950s. Photo, J. J. Koranda.

North Slope Experiences

In May 1952 I first appeared at Barrow at the old ARL facility where I studied the chemistry and biology of the Barrow area lakes with Prof. G. W. Prescott. Dr. Ira Wiggins was director of ARL then. When I drilled into Fresh Lake near the lab, there was almost no water in it, and ice extended essentially to the bottom. I found some yellow liquid down there and analyzed it hardly believing what I had found. I stayed at ARL that year until December with Prof. Prescott and we went to Ecuador shortly after Christmas to make another study of the high Andean lakes in that country. Fresh Water Lake was half frozen when we left. The lab was an interesting place then as it always is, and the roots in the Navy and Seabees were still evident in the huge Quonset buildings. We were called Bughunters by the base workers and many of them attended the seminars that were given in the library on the upper floor of the lab Quonset.

In the fall when I stayed after the main group of investigators had left for their academic homes, I became acquainted with several of the Eskimo workers at the lab. Pete Sovalik and Chester Sivik were good friends and we had many long conversations as the fall days slipped into the darkness of winter. Pete and I went out on the ocean ice that summer to see a whale being butchered and I was quite impressed by the whales' internal organs and their huge size. During the previous summer I had analyzed the water in Ikroavik Lake south of Barrow village, where Dr. Wohlschlag had been studying the small population of whitefish that lived in that lake. I would drive through Barrow village on those trips to Ikroavik Lake and usually woke everyone up as my weasel chugging noisily through the sleeping village. We analyzed the small lake next to the village which produced a tremendous bloom of algae in the summer that made the water almost as thick as syrup.

During the successive years when I worked at the lab, in 1953 studying the brown lemming, and in 1955 when we began work on the productivity of tundra vegetation, I always found it to be a source of adventure and interesting experiences. I wrote my Master's thesis on the old beach ridge surrounding Central Marsh just south of the lab in 1954. 1953 was a lemming high year and the little fellows were all over the camp, looking for some thing. For some reason I never got airsick on those whirling flights except once. We were going to the upper Utukok River, and for some reason Max Brewer wanted to go along on the first planeload with me. We went down the coast to Wainwright and then inland to the Utukok River. When we were about 3/4 of the way there, Max lit up a cigar and by the time we made a bumpy landing on a gravel bar, I was just about ready to give up a good breakfast. Later I camped at the mouth of the Pitmegea River with Henry Childs and studied the interesting vegetation there. We were reading an account of an early explorer named Diamond Jenness and he had camped at the same location. He mentioned that strong winds occurred there, and within two days we were in a windstorm that took everything down to the ground. I went to the beach where there was

a lot of driftwood, and hauled some large trunks to our campsite, and built a huge A-frame over the tent and suspended the tent within it. When the pilot landed to pick me up, he asked what that was over our tent, and I said it was just standard lab issue.

I worked until 1959 at the lab, and graduated from the Univ. of Tennessee the next year. During three summers I had studied the vegetation of the Franklin Bluffs on the Sagavanirktok River, and wrote a dissertation on that subject for the doctorate. I moved to Palmer, Alaska in the summer of 1960 and made one trip to Barrow in the early sixties. Later I made a survey of natural landmarks on the North Slope for the National Park Service, and also took part in the Tundra Biome studies in the mid-1970s. By that time the new lab, NARL, was there and it was quite elegant compared to the beginnings in the two-storey Quonset. In the more than 20 years of experience working out of the Barrow laboratory, I have made lifetime friends, and had some adventures that I often wonder if they really occurred. The people of Barrow village have always been friendly and interested in what we were doing at the laboratory, and I have admired their ingenuity and strength demonstrated in their life style on the Arctic shores. One spring I was particularly thankful to a Barrow Eskimo when Dr. Pitelka and I drove our weasel to the Inaru River. We travelled on a tractor trail on which coal was hauled to Barrow from the Meade River coalmine. When we got to the Inaru River and turned around, we promptly broke a track on the weasel. We walked for about 5 hours along the tractor trail when we noticed a sled coming up on us from the south. An Eskimo had a sled full of ducks, and he invited us to ride on it. As we neared Barrow, the dogs sensed they were home and ran as fast as they could. We entered the village at such a speed that all we could do was roll off the sled, and yell "Thanks a lot." We got a few laughs in the village over the Three Stooges entrance.

I congratulate the present administration at the Barrow laboratory and wish them continuing success in their program. My small role in the research conducted at the laboratory in its early days was probably the most interesting work I have ever done. In subsequent years, I worked in the S. Pacific on the islands where nuclear tests were conducted, and later spent several summers in the Aleutian Islands, but the spirit of exploration and adventure was the strongest in those summers on the North Slope. I was on the Kadleroshilik River with Tom Cade once, and a wolf looked into our tent, and I met him eye to eye at three feet. You can't beat that for thrills, not even on the Discovery channel on TV. Thanks for all of those times.

John J. Koranda

Mr. John Koranda
19522 Via Real Dr.
Saratoga, CA 95070

Recollections of Barrow

Kou KUSUNOKI

My first visit to Barrow on October 14 1959 was not from the South but from the Beaufort Sea, leaving the Arctic drift station Bravo on Fletcher's Ice Island T-3 on board a Navy R5D airplane and landed near the DEW line station. Since May 1959 I was on T-3 to carry out Arctic research project of Hokkaido University (Sapporo, Japan); project leader was the late Dr Ukichiro Nakaya (physicist) who made a contract with the Air Force Terrestrial Sciences Laboratory (Chief: Col. Louis DeGoes) through the Arctic Institute of North America (AINA), incidentally I was a temporary employee of AINA. In the middle of October 1959, the Office of Naval Research (ONR) conducted a sort of VIP inspection flight to station Charlie on the sea ice and Bravo on T-3. It was natural that Dr Max Brewer, the then Director of Naval Arctic Research Laboratory (NARL), accompanied this inspection group. We stayed two nights at the NARL sharing a room with Col. DeGoes.

Next morning we had a small conference at the Lab under the chairmanship of Dr. Max Britton, Head of Arctic Project of ONR; I gave a brief talk on my oceanographic observations on T-3. In the afternoon we visited the village and I met native people for the first time, I never thought that I might work with them in later years on the Ice Island Arlis-II. In the evening a party with native people was held at the Lab and we were invited to the village to watch their dancing at the Barrow Village Theater (I'm wondering if still there). Together with this group I went down to Washington, DC, where the office of AINA is located.

I stayed again on T-3 from September 1960 to January 1961 to finalize our project. The island was located about 100km west of Barrow. On October 29 1960 an emergency flight of Cessna (NARL plane piloted by Bob Fisher?) was made to rescue a heavily wounded scientist on T-3. At this time the Air Force was responsible for logistics, so I took a direct flight between Anchorage (Elmendorf AFB) and T-3 with a refueling stop at Barrow. My oceanographic work was assisted by Jiro MUGURUMA (May 1959 to September 1960) and Keiji HIGUCHI (March to September 1960), both from Hokkaido University and they also worked on the

ice physics of Ice Island. Both took Ph.D. from Hokkaido University; Muguruma was a professor of physics at Tokyo University of Fisheries and Higuchi was a professor of hydrology at Nagoya University, they had retired from the University and got new assignments.

From December 1963 to May 1965 personnel of Hokkaido University stayed on the Ice Island ARLIS-II (Arctic Research Laboratory's Ice Station No. 2) for oceanographic observations of the Arctic Ocean and the Greenland Sea. This research contract was made between Hokkaido University and the Office of Naval Research through AINA. I was in charge of the project and the ARL (Director Max Brewer and Assistant Director John Schindler) gave us a full support. Two assistants and I had to stay several weeks at ARL, waiting for a flightworthy weather. Finally we arrived Arlis-II via T-3 on December 22 1963 on board the R4D-50776 piloted by Bob Fisher. We met Ray and Arthur Ipalook there, Arthur soon replaced by Percy Nusunginya. Our oceanographic work was continued to the "official decommission" of Arlis-II on May 11 1965 in the Denmark Strait. I stayed the island twice, from December 22 1963 to May 13 1964 and from January 24 to May 11 1965. During the first period Akito KAWAMURA (graduate student of marine biology) and Hiroji FUSHIMI (geology student) assisted the research; Kawamura stayed about one year and Fushimi for the whole period. At present Kawamura is a full professor of marine biology at Mie University and Fushimi is also a professor of environmental science at the University of Shiga Prefecture.

In April-May 1964 a Japanese group of scientists and press reporters visited Arlis-II and ARL, so the activities of ARL and my group were introduced in Tokyo Shimbun (newspaper) later on. At that time we witnessed of the retreat of Norwegian party led by Bjorn Staib who aimed at the Pole. During the summer of 1964 two researchers of Hokkaido University participated in the project; Takashi MINODA (marine biologist at Fisheries Faculty) and Kazuo FUJINO (glaciologist at the Institute of Low Temperature Science), they became full professors in late years and retired few years ago.

During my second visit to Arlis-II Shoji MIURA (veterinary student, now a dentist in Sweden) and Fushimi assisted; Miura and I left Barrow on December 22 1964, staying overnight at Alert,

and arrived the island on the 24th. During the final leg of the drift in the Greenland Sea, flights of "776" were from Iceland and the runway on the island deteriorated. The last landing of 776 aboard Max Brewer was on April 19 and then paratroops were the only means. Hectic evacuation operation was carried out by the USS *Edisto* which returned from the Antarctic. The ship left Arlis-II at 0730 hrs on May 11 1965 at 66°40'N and 27°30'W. Next morning we arrived at Keflavik (US Navy Base), among us were Raymond Ipalook, Frank Akpik, James Itta, and Percy Nusunginya.

My wife and I visited Barrow on August 24-28 1991 and on September 6 1992 during the cruises of Northwest Passage of MS *Frontier Spirit*. Thanks to Dr. Thomas Albert we could visit renovated UIC-NARL Facility, and Mrs. Jana Harcharek arranged to meet Percy. During one of my past visits to Barrow I met Dr. John Kelley for the first time and he suggested me to write this memoirs. In those days I am interested in a Japanese man Keisuke ABE (1861-1898) who is supposed to be the first Japanese who wintered at the Point Barrow Refuge Station in 1891-92. In August 1891 muster-roll of the US Revenue Steamer "Bear" (Captain M. A. Healy), it says "Re- enlisted for general service and transferred to Pt. Barrow Refuge Station as cook. 14th inst. (August)." My question is how long did he stay there. Barrow is not a faraway place for me. Congratulations to NARL, ARL, and UIC-NARL!

Kou KUSUKOKI: Kamisagi 5-27-28, Nakano-ku, Tokyo 165, Japan
(Professor emeritus, National Institute of Polar Research, Tokyo.
Fellow, Arctic Institute of North America)

Fairbanks, Alaska 25 July 1997

Dear Barrow Residents,

During my 15 years at Barrow (1965-1980) and 12 years (1988-1980) for my wife Nicole we enjoyed working at the NARL and living alongside your Native Community.

It was always a great pleasure to be constantly invited to share your customs and annual festivities at the whaling season time. Nicole particularly enjoyed the good-hearted laughs and jokes shared with Mary Lou Leavitt, ^{Nellie} Nellie Forbes, Harry Brower, Kenny Toovak, Frankie Akpik, Benny Nageak and she warmly remembers wearing the 2 beautiful parkas made for her by Annie Brower.

We wish we could be there at this ceremony and reminisce of these good times. But we are pleased to see that many of our former co-workers have become leaders of the prosperous Barrow Community.

To All of you our sincere admiration.

Franchy "Alain" Tarrikuluk
Alain LeCloirec
Nicole Larcon-LeCloirec
P.O. Box 81454
Fairbanks, AK 99708

“Fairbanks, Alaska, 25 July 1997

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During my 15 years at Barrow (1965-1980) and 12 years (1968-1980) for my wife Nicole, we enjoyed working at the NARL and living alongside your Native Community.

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Franchy "Alain" Tarrikuluk
Alain LeCloirec
Nicole Larcon-LeCloirec

P.O. Box 81454
Fairbanks AK 99708”

450 Palm Circle West
Naples, Florida, 34102
May 25, 1997.

Mr. Richard Glenn
The Barrow Arctic Science Consortium.
P.O.Box 577
Barrow, Alaska 99723.

Dear Mr. Glenn:

I always feared that the Naval Arctic Research Laboratory would eventually be disbanded. That it has continued under the management of the Ukeagvik Iñupiat Corporation is a most remarkable and propitious event for the scientific community of the United States. I am deeply moved that citizens of Barrow and the North Slope Borough's Department of Wildlife Management took on the responsibility of continuing the scientific traditions and activities of what is now recognized as an important center for polar research. The 50th Anniversary of the Naval Arctic Research Laboratory is a celebration not only of the founding of the UIC-NARL Facility but of the good fortune the citizens of Barrow have bequeathed the people of the United States.

The inception of NARL recalls two men, Laurence Irving and Pete Scholander whose enthusiasm, enterprise and partnership with the people of Barrow set a standard for physiological studies on Arctic adaptations. It is with this in mind that I relate the events that led up to their arrival at Barrow. Larry and Pete were not given to talking about themselves and at 88 I may be the only one to that can relate the events. Both were my superiors at the Proving Ground Command, U.S. Air Force in Florida, 1943-47. During these war years the only way to carry out low temperature tests was to fly at altitudes of 30,000 feet over Florida. Our laboratory was a stripped-down B-17. Scholander with his many years of polar studies in Greenland and Spitsbergen deplored the lack of a proper research laboratory in North America. Because of its many islands, remoteness and wildlife, the Canadian High Arctic appeared to be most suitable. The site chosen was Prince Patrick Island. It was planned to use surplus military buildings, equipment and supplies and transport these in gliders to the area selected. At this stage of WORLD WAR II there was a glut of military equipment and supplies that could be adapted to setting up field camps and a laboratory.

Towards the end of the War, Lt/Col. Laurence Irving met with Dr. Jack Field, a colleague at the Office of Naval Research, in

Washington, D.C. Whatever their conversation, Larry Irving's interest in establishing a polar research laboratory in Arctic Canada was diverted to the Naval Station in the Naval Petroleum Reserve No. 4 near Barrow, Alaska.

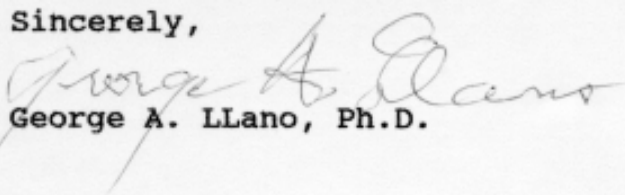
I had to withdraw from the Irving-Scholander team that went to Alaska the first years; I arrived after Irving & Scholander were replaced by George MacGinitie. My work was carried out at Wainwright, Anaktuvuk Pass, Umiat, Chandler and along the coast with the field support of the Arctic Contractors at NARL and later extended to the Aleutian Islands with the assistance of the U.S. Navy and Coast Guard Service at Adak.

My association with the Barrow community was limited. I still recall the warm friendship and useful wilderness guidance from Simon Paneak and his comrades at Anaktuvuk Pass where I spent most of my time. My recollection of the activities at NARL under Irving & Scholander was the personal working relationship they had with the people of Barrow, learning much from them and accepting them as colleagues. These early years are well set forth by Laurence Irving in "Birds of Anaktuvuk Pass, Kobuk and Old Crow", Smithsonian Institution, 1960, and in Per Frederick Scholander's autobiography, "Enjoying a Life in Science", University of Alaska Press, 1990.

Later as Program Manager for Biology and Medicine, Division of Polar Programs, National Science Foundation, I organized and funded Arctic research focusing on the facilities and personnel of the University of Alaska, Anchorage and Fairbanks, and the Naval Arctic Research Laboratory. These programs included "Man in the Arctic", the "International Biological Year Program" and "PROBES".

It would be good to join the Iñupiat at Barrow in August for the 50th Anniversary of NARL and for the opportunity to greet Alaskans and other scientists with whom I was once associated through the Naval Arctic Research Laboratory.

Sincerely,


George A. Llano, Ph.D.

α



United States Department of the Interior
GEOLOGICAL SURVEY



WATER RESOURCES DIVISION
Oregon District
10615 SE Cherry Blossom Drive
Portland, Oregon 97216
[http ://www.oregon.wr.usgs.gov/](http://www.oregon.wr.usgs.gov/)

May 30, 1997

UIC-NARL and
The Community of Barrow
Barrow, Alaska 99723

Dear Friends:

From 1993-1996, I was involved with an investigation of the hydrology in the vicinity of UIC-NARL. During the summers of 1993, 1994, and 1995, I was fortunate enough to visit Barrow. What a highlight of my career as an earth scientist! The spirit of Barrow—especially the people that *are* the community—is truly special. It is niche for the unique, it is enriching, and it is exhilarating in so many ways for someone who has spent a lifetime at a latitude of 45°!

The UIC-NARL facility was a warmhearted and truly appreciated oasis during my time in Barrow. It was always a pleasure to return “home” after long, cold hours in the field. I spent many pleasant hours absorbing the general ambiance, *as* well as the wealth of fascinating pictures, maps, artifacts, and memorabilia.

I would like to congratulate the entire community of Barrow on this 50th anniversary of the NARL facility. You have contributed immensely to scientific growth, and you have left indelible marks in the hearts of many.

Sincerely,

Kathleen A. McCarthy, Ph.D.
Hydrologist



Barrow Naluqataq, 1951. Photo, J. J. Koranda.

Picking Critter From the Sea - NARL + Beyond 1952-71

At my left on the work desk two old wooden vegetable cartons serve as a sort of book case. Painted red, they have white lettering on the ends, "KEEP FROM FREEZING." They constantly remind of a couple of decades of work at, about and through NARL.

For us Trojans (the L.A. Ones, not the Turkeys), awareness of NARL's existence came mainly from the MacGinities' use of the Hanncock Library from time to time. Bill Mayer [W.V. Mayer] went up summer of '51 studying small mammals. When Olga Hartman (expert on bristle-worms and occasional advisor since graduate school days in Berkeley) said, "You better get up to the Barrow lab before it closes", I applied to look for marine crustaceans and things on them with Charles Horvath for summer '52. Happily we got approval and at the beginning of summer went north (with a critical stop at Ladd Air Force Base) starting about two decades of high latitude activity which with all the field workers was to involve about 40 of us.

Summer '52 was a principal learning period with Pete Sovalik, mostly, teaching us where we could go effectively for close-to-shore zoological work and, in many respects, how we should do it. And that was the season we saw a dazzling celebration of the 4th of July by the Barrow townspeople. We became acquainted with other research teams that would be active on the north coast for a long time, some of them with which we would be working. We probably saw most of the Stanford fish groups under Norm Wilimowsky and Curly Wohlschlag and the Cal-Berkeley bunch, working on other vertebrates with Frank Pitelka. The weekly evening seminars told us about others' projects~ their objectives and some of their results. The Stanfordites' conclusion that there was a good population of food fishes, but not enough to support a commercial fishery deserves continued attention and consideration as to how the population endures petrol pollution.

We were hardly home from the '52 Barrow work when Charles Horvath went north again to take part in the setting up of the Air Force drifting station T-3 in the Arctic Ocean, a program that would later involve NARL.

Summer '53 Norm Wilimowsky with Adair Fehlman set up The Cruise of the Red, a landing craft sampling expedition from the eastern Alaskan coast to Barrow and Charles was part of the team. They took a significant collection of fishes and invertebrates; interestingly they did not observe any kelp beds. At NARL J. Lawrence (JERRY) Barnard (later Smithsonian amphipod curator) and Donald J. Reish, an Olga Hartman student of bristle-worms, later a top authority on the use of marine invertebrates as indicators of marine pollution, I was lucky to recruit for the summer's work. The big accomplishment was a study of the organisms of Nuwuk, a little lake totally marine in character just below the point of Point Barrow.

The '54 season was special in many ways. Co-worker was Emery Swan, a contemporary of Berkeley graduate student days and summer colleague at University of Washington's Friday Harbor Laboratories. Again Norm Wilimowsky planned a landing craft expedition. This one was west of Barrow to Wainwright and Kuk Inlet and back. In the group was G. Dallas Hanna of California Academy of Sciences, ever pleasant to be with if just for a cup of coffee. On the return leg, close to the Will Rogers - Wiley Post site, we discovered a kelp bed, the first reported in the Alaskan arctic. The late E. Yale Dawson (not along) provided reliable identification of the plants.

When we got back to the lab, there was waiting a tray of sea water with a lot of whale lice, curious parasitic amphipods taken by some Barrowites from a gray whale. It was my first good supply and they were ornamented as a British Museum specialist had found with some on Greenland narwhals with collar ciliates, protozoans in which I am especially interested. Also about that time, if my memory is correct, there was a very successful walrus hunt by Barrowites and there were stacks of walrus parts at several places in Barrow.

I made just one mostly darkish visit to NARL, an Easter-break trip during which I met the °C-°F junction [forty below]. And on one of the trips I met Betty Crocker (I forget what number); she and spouse were visiting DARL, a friend of theirs.

Floyd Earl Durham, a specialist in very small mammals when we were graduate students at Berkeley, converted to whale research while on our project - starting first during a run from Barrow west to one of the capes. He subsequently did his research with the Los Angeles County Museum of Natural History.

The drifting station work had varying connections with NARL, typically well covered in Reed and Ronhovde's Arctic Laboratory. Charles Horvath began with three trips totaling 14 months from late 1952 into 1956 to T-3, Fletcher's Ice Island, a Canadian glacier product with surface about five by nine miles. When first occupied well north of Barrow, in its arctic circuit it got to about 70 miles from the geographic North Pole and then east and south till it practically scraped the shore of east Alaska and finally, after a drift west and north, went east and around the top of Greenland and down into the Titanic's area.

Charles developed a marine mainly-zoological program coping with many tough problems: working through 10 feet of ice, drilling again when scraping floe ice demolished the original well, and surviving many more difficulties.

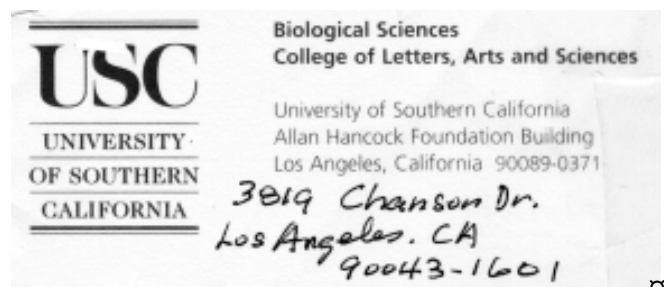
His methods were pretty consistently effective for a couple of dozen other field workers on the project into 1971. Management was originally with Arctic Aeromedical Laboratory at Ladd Air Force Base outside Fairbanks but shifted to the East Coast as T-3 crossed several meridians, and service flights connected with such places as Thule, Greenland. A crash in a glacier area was the most energetic of Charles' many thrills.

Air Force ended its T-3 activities in 1955 or early 1956, but in 1959, when T-3 was close to the east Alaskan shore, ONR started a program. This included some ice floe sites as well. NARL was very much involved. Roger Lewis was our first ice stationer in this series; we were involved in it until 1971 and one of our people made the voyage around the top of Greenland. The workers of our group included very varied talents. John Tibbs did later work on radiolarians of Pacific Ocean / Antarctic; Joe Arditti became an authority on tropical orchids. At the University, office and laboratory were led particularly by

Stephen Geiger who later was managing editor for all of the journals and books of the American Physiological Society.

A bit of correction of Reed and Ronhovde's account of George MacGinitie in Arctic laboratory, which does have a great amount of fascinating and useful history. Although he was an outstandingly good and tremendously helpful ecologist, George MacGinitie was not "Dr." The story we have heard is that a Stanford professor on his doctoral committee was not satisfied with the dissertation he submitted; it lacked statistical analysis or at least did not have enough to please the critic. The many biologists who have been helped significantly by the information that MacGinitie provided, for at least a few it was the start of a research career, mostly would not even recognize the name of the critic. The late Paul Saunders (professor and department chairman) and I proposed that USC award George an honorary doctorate - but the graduate dean through whom we submitted our proposal never even acknowledged receiving it. These events give some support to Robert Hutchins' remark "professors are somewhat worse than other people, and scientists somewhat worse than other professors." (note: the dean had been a professor of chemistry) and to my belief that in link with dunciad, collective patronymic for dunces, there is needed deansiad, that bunch of deans (ah, yes, there are some good ones). I believe George also was not professor, but head of Cal Tech's marine station. In that role he certainly had mere productive influence than a lot of university people.

J. Mohr



From: JoAnn B. Murphy <ffjbm@aurora.alaska.edu>
To: basc@barrow.com
Subject: NARL 50th anniversary
Date: Thursday, August 07, 1997 3:47 PM

To the People of Barrow
C/O Barrow Arctic Science Consortium
Attn: Dr. John J. Kelley, Coordinator

It is with great pleasure that I send you a few of my special memories from my years at the Naval Arctic Research Lab - and my association with the people of Barrow. Bob and I lived and worked at NARL from March of 1962 through December 1968 (for him) and February 1969 (for me). He as a pilot - I in the office.

Throughout these years we met many fascinating and interesting scientists and government people, but it was the warm and friendly people of the village who made us feel especially welcome and at home in the Arctic.

Bob and I arrived in Barrow with one daughter and when we left we had three. During this time we had the most wonderful babysitters: Ruth Pikok was the first super babysitter. She shared her friendliness and her culture with us. Carrie Kignak was our last babysitter. She was a warm, friendly grandmother to my three girls, full of laughter and good cheer.

One day in the office I asked Kenny Toovak what the word Anaktuvuk meant in Eskimo. After several mumbled answers which I did not understand, and with a rising blush in his tanned cheeks, he blurted out "caribou puckies." Now it was my turn to blush. I really had no intention of embarrassing him. Regardless of my faux pas, he continued to patiently attempt to answer all of my curious questions. He is a true gentleman.

There are many warm memories of our years in Barrow. There are several hair-raising memories as well.

Like the time Bob and Mal Staley took off from T-3 in the R4D to fly a load of fuel oil to Arlis II. They lost an engine on the take-off with 33,000 pounds. The one engine that continued to turn was definitely under stress. The airplane responded to the situation and did not immediately fall out of the sky. What happened though was after takeoff the runway lights headed into camp (weasel headlights). Bob could not see the

runway on the first pass back to land — nor on the second. By this time both Bob and Mal were in cold sweats. Would the “good” engine keep them aloft for a third go ‘round? Thanks be to the powers above and the mechanics who serviced the plane; it did. The weasels got back into position and there was enough light for the plane to land.

A second thrilling story Bob told me was when he landed a fully loaded C-130 on unprepared sea ice and the plane came to a halt less than twenty feet away from a thirty foot ice berm. I cannot remember if that trip was for Arlis IV or for Beaumont out of Goleta. I do remember that Bob thanked his lucky stars that the Herc stopped when it did.

There are many little things I remember that occurred around the lab. The baby seal I donated a baby bottle to so he could be fed, have a radio transmitter inserted, and then die of peritonitis. The eggs I boiled for Bill Maher to feed baby birds. The tundra orchid Frank Pitelka brought to me - so small - so fragile - so beautiful.

In the words of Riley Sikvayuguk when I asked him why he quit a good job in the states to return to Barrow and work as the Lab’s expeditor (and a good one he was) “because Barrow is home.”

It was for me too. Thanks for letting me share.

JoAnn Murphy

Barrow, Alaska 99723

14 July 1997

Dr. John J. Kelley
Institute of Marine Science
UAF

Dear John:

The fiftieth anniversary of NARL provides a unique chance to review some vignettes of NARL history that otherwise could vanish into the mists of time.

MIDDLE HISTORY NOTES

It was on the 18th of May 1968 that I arrived as a graduate student from Fairbanks, on an R4D supply flight. That year was memorable because of Wally Herbert's British Trans-arctic Expedition by dogteam in progress, the simultaneous re-surfacing of both civilian and Navy airstrips, and NARL's last full season housed in Building 250, before the completion of Building 360. In Alaska's statewide history, 1968 marked the announcement of the Prudhoe Bay petroleum discovery. The year was notable too, for confounding Frank A. Pitelka's prediction that it would be a season of lemming abundance. Nobody today could be expected to remember that my original Master's research in Biology at the University of Alaska was designed as a study of jaegers' incubation schedules, to compare their performance at low environmental temperatures with Rudy Drent's better known Dutch Herring Gulls, members of the same family of birds.

Steve MacLean arrived from Berkeley near the end of May 1968, followed on the first of June by Pitelka himself. Both Steve and Frank took an interest in my plight, for it was immediately clear to them from examining the tundra along the gaswell road, that the brown lemming was not going to be abundant in 1968 after all; hence there would be little or no breeding by either Pomarine or Parasitic Jaegers that season. Instead, they invited me to join the UC- Berkeley group that Dr. Laurence Irving later called "the *Calidris* apostles" in honor of the genus name for Barrow's four most prominent species of breeding shorebirds. No grad student career at NARL was more fortunately re-directed by an unforeseen turn of events. My re-directed study of incubation by Dunlins, *Calidris alpina*, contributed to the Berkeley group's interests in ecological energetics, and to learning how the four species of the genus *Calidris* partitioned resources during their breeding season residency on coastal tundra. It was an extraordinary privilege to become, however informally, a disciple of Pitelka, and a junior partner to Steve MacLean, while formally connected with George West, Larry Irving, and Brina Kessel in Fairbanks. Those associations were enriched by Dick Holmes' taking me out to his study areas at Ikroavik Lake during his brief return to Barrow, then further enriched by the arrivals of Martti Soikkeli, a Dunlin specialist from the University of Turku in Finland, and Uriel Safriel from the Hebrew University in Jerusalem on a post-doctoral project to study Semipalmated Sandpipers (*C. pusilla*). Imagine trying to design a richer atmosphere of ideas in ecology and evolution than that

surrounding the the lively discussions over meals at the old NARL Mess Hall. In short, it was the golden age of shorebird studies at Barrow. Numerous contributions to the literature and understanding of breeding biology, energetics, and social systems made it appropriate to call Barrow “the shorebird capital of the world” in those years.

Over my five research seasons at NARL, 1968-72, we transient investigators developed countless friendships locally, too. Kenneth Toovak, Sr., Chester Lampe, Frankie Akpik, Pete Sovalik, and Merle Solomon were in this category. NARL’s young expeditors included Randy Crosby, who is a community leader in Barrow today. All kept us from making too many outrageous mistakes, and kept us from taking ourselves too seriously. Fresh graduate students arrived in these years, notably Van Remsen, Tommy Custer, and Pete Myers. There were illustrious field assistants: Mark Oberle, Bjørnulf Christiansen, Jeff Myll, Lew Pitelka, and Steve MacDonald. Another highlight of our NARL days was the sojourn by artist William D. Berry, whom Pitelka enlisted to illustrate shorebirds in full breeding displays.

Another key event in those years for some of us investigators was the arrival of Big Science, in the form of the Tundra Biome of the International Biological Programme (IBP) in 1969-70. Bioenergetics studies of vertebrate consumers on the tundra were engulfed by Big Science. Mathematical modelers could frolic with data coaxed out of our quantitative natural history studies. Tundra Biome studies of ecological processes were an excellent vehicle for stimulating interdisciplinary thinking among investigators, a crucible for developing cooperation, and an ideal system for keeping specialists from sinking too deeply into incomprehensible jargon of scientifically narrow understanding. Jerry Brown deserves credit for inspiring hard work and innovative thinking among the IBP fraternity of investigators. Observers of this era of scientific work at NARL would have had any stereotypical images of scientists’ being loners and self-serving *prima donnas* shattered by the intense cooperative practices among Tundra Biome participants.

NARL’s unique dominance of arctic research began to loosen, after about 1970. This loosening was no doubt accelerated by the Prudhoe Bay oilfield development, and the comparative accessibility of other arctic intensive research sites, such as Toolik Lake Research Station. Possibly, too, science as an arctic or regional enterprise became less tolerant of charismatic leadership of the sort exemplified by NARL Directors from Larry Irving through Max Brewer and John Schindler. While this speculation might suggest further analysis, it seems safe to assert that the spirit and the personality (including in the sense of personnel) of NARL were exported widely to good effect. Bob Elsner, for example, reminds us how the investigation of ancient gases trapped in ice and amber began with Pete Scholander and Larry Irving’s elegant scientific ideas in NARL’s early days of the 1940s and 50s. Elsewhere, NARL’s little-known legacy to Outer Continental Shelf environmental studies in the years 1975-1981 has been noted, along with its continuing influence upon certain industry-funded studies even today (Norton and Weller, 1997).

More recently, if on a more modest scale, bioenergetics studies of Barrow's sandpipers have had the interesting history of a boomerang's flight. That is, Pitelka and I, and our respective grad students, Pete Myers and Stan Senner, all expanded our interests, originally generated at Barrow, from breeding, to the energetic determinants of shorebird biology outside the breeding season. Stan's contributions in the late 70s were in showing how much energy Pacific Dunlins and Western Sandpipers had to acquire during spring stops in the intertidal expanses of the Copper-Bering River Deltas of eastern Prince William Sound in southcentral Alaska. Pete Myers then exported our line of inquiry in the 1980s to Delaware Bay, where he discovered the critical dependence by Sanderlings and Knots upon horseshoe crab (*Limulus*) roe for Atlantic spring migration to arctic breeding ranges. European researchers also borrowed our focus on migratory energetics of shorebirds, to develop the idea of critical habitat conservation. Again, the seminal ideas originated from NARL and Barrow. The 1989 *Exxon Valdez* oilspill brought shorebird energetics studies back to Alaska in dramatic fashion. In Prince William Sound's rocky intertidal zone, Stan and I found that two Beringian species of shorebird—Surfbirds and Black Turnstones—were dependent on roe of the Pacific Herring, to energize the final stages of their spring migrations to arctic and alpine breeding habitats (Norton et al., 1990).

RECENT HISTORY NOTES:

When Ilisagvik, the community college of the North Slope added natural sciences to its teaching faculty capabilities, I was pleased to move back to Barrow in 1990. In the spring of that year, the community held a symposium on science education, organized by Richard Glenn, Irene Murphy, Tom Albert, and Rex Okakok (Norton, ed., 1992). What remained of NARL, then 10 years after its transfer to Ukpeagvik Iñupiat Corporation (UIC) was viable but minimal. I was able to locate my teaching laboratory into L-114 of Building 360 that spring. By combining three former NARL stockrooms into one, I was able to help UIC realize a net gain in useable space, despite UIC's donating the use of my double lab to the college's science instruction for over a year. L-114 became a happy place for teaching sciences to college students, benefiting from the nearby biologists with the North Slope Borough's Department of Wildlife Management, as well as from the small volume of seasonal scientists that continued to use UIC-NARL through its leanest years.

Some of Barrow's scientific fascination shifted to the original quonset hut of NARL, the so-called Arctic Research Facility (ARF), Building 350, once Pitelka's domain, now used in whale research by the Department of Wildlife Management. In cooperation with UIC, we meanwhile converted the old fish bowl area of Building 360 into a 1600 square foot exhibits gallery by 1993-94, and used that gallery in implementing a new curriculum in Museum Studies. Until early 1994, Natural Sciences and Museum Studies were the only college courses taught at NARL. Then the college entered an explosive growth phase, was put under corporate ("privatized") management, and its vocational-technical programs and all administrators moved from downtown Barrow to the NARL complex. All but the Science Lab Wing of Building 360 was leased to the college by UIC. The old Personnel Wing became mostly a college student dormitory, the exhibits gallery was

dismantled and made into a lounge, and pressures on all space in Building 360 increased.

During a Sabbatical Assignment to the Arctic Institute of North America at the University of Calgary in 1996-97, I learned to appreciate the power of oral tradition in connecting historical consciousness to the affairs of northern indigenous peoples. As scientists, of course, we are trained to revere the written tradition. Yet the written tradition in key areas of northern understanding is weak, incomplete, and unstable. Traditional knowledge in non-literate heritage systems can be a stabilizing force and can bring together areas of understanding that western systems treat as disjunct subjects. In many northern endeavors, oral and written traditions could accommodate and complement one another for wholeness. T.S. Eliot described historical consciousness as not so much a sense of the pastness of the past, as of its presence. On the occasion of NARL's 50th anniversary, I daresay elders of both literate and oral tradition are engaged in celebrating Eliot's presence of the past.

For reasons that elude my understanding, the community college that now occupies much of the NARL camp has cultivated virtually no historical consciousness about NARL's first half century of endeavor. Its clean slate approach was long evident in the unadorned walls of offices and corridors in the college's end of Building 360. Breaking with the past is not how I would have chosen to serve the college's North Slope students. Perhaps our observance of this anniversary will re-kindle awareness and interest in the vitality and continuity of past ideas, to the benefit of future students.

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□

Sincerely,


David W. Norton, Ph. D.

Pitelka: A Glimpse of his Era and Aura

It is hard to overstate the importance of 30 seasons of terrestrial ecological research conducted by Professor Frank A. Pitelka and his University of California, Berkeley, students at NARL. Whenever he was in residence at NARL, Pitelka was the center of a lively group, serving as its magnet and its catalyst for intense discussions on topics both within vertebrate ecology and far afield. If NARL's first 50 years featured informal learning within "the university in a Quonset hut," Pitelka's tenure (1951-80) qualifies him as NARL's most durable and colorful seminar leader.

As recounted elsewhere (Norton, Letter, 1997, this volume) an unexpected absence of lemmings and their predators in 1968 led to my being adopted into Pitelka's "Berkeley" group, then focusing on shorebird ecology at NARL. Being a University of Alaska student meant that, unlike students meeting graduate requirements determined by committees led by Pitelka at Berkeley, mine were set by George West, Laurence Irving, and Robert Weeden at Fairbanks. Pitelka admired each of those biologists. Informally advising one of their students in field research perhaps offered Frank a convenient link with those Fairbanks colleagues. In the final year of my Ph.D. research (1972-73), one of Pitelka's prominent graduates, Steve MacLean, joined both the University of Alaska faculty and my Graduate Committee. Vital Berkeley-NARL-Fairbanks ties outlasted my graduation, through the synthesis of U.S. Tundra Biome research conducted under the International Biological Programme (Brown et al., 1980; Brown, this volume).

At NARL, Pitelka was distanced from formal lecture-hall teaching, academic intrigues, and committee deliberations that undoubtedly constrained his on-campus activities. Although I admittedly knew little of Pitelka in action on his California campus, I was influenced by this leader among 20th century ecologists at work in his favorite

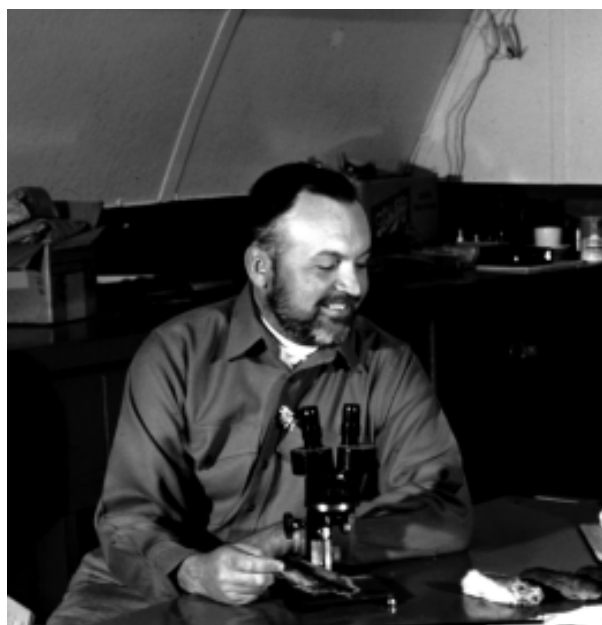


Fig. 1. Frank A. Pitelka at the Lab in the mid-1950s (Photo, John J. Koranda)

research habitat. In NARL's relaxed setting, Pitelka's repertoire was by turns charming, witty, and provocative, but never dull. Throughout the five field seasons (1968-72) that we shared, I learned to appreciate his quality of being, in the best sense, a fussy man. That is, he was 'fussy' about undertaking everything with consistent attention to detail and to style. Pitelka's reverence for English—his second language after native Czech—was for me his endearing hallmark. Even Pitelka's spur-of-the-moment conversations assumed

the quality of performances staged for the benefit of his extended entourage. He regularly paused, groping for the most powerful word or phrase to express an idea. Like Joseph Conrad, another native Slavic-speaker turned English craftsman, he often succeeded brilliantly. For example, to express his attitude toward the research community's infatuation with hypothesis-testing to the exclusion of natural history studies, Pitelka struggled during a dinner conversation to find a sufficiently scathing comment. "It's...it's...the, the.., well, let us hope that we are at the *nadir* of a fad." On another occasion, Frank debated at length over which word borrowed from French best praised the flair of a particular investigator: was it *panache* or was it *élan*?

His pauses and struggles to find the ideal expression betray, I suspect, Frank's searching through his immense and rich lexicon, not just for words, but for accompanying gestures with which to round out whole-body performances. It is ironic that some listeners, failing to appreciate Frank's fussiness with his adoptive language as that of a *virtuoso* performer, might regard his expressiveness as pompous or flowery. In fact, his condensing whole paragraphs of ordinary chatter into a carefully chosen phrase strikes me as the exact opposite of pomposity. He fussed and crafted in hopes of inspiring his students to develop their own economy of prose. Professor Pitelka illustrates that there is no contradiction in loving to talk and write, while hating wordiness.

Clear thinking and its concise oral or written expression thrilled Pitelka. Laurence Irving pencilled in the margin of an early draft of my dissertation a comment meant to

criticize the length (pomposity) of my introduction: "Pitelka and his [shorebird] *apostles* may not *need* so much of your spirited praise. Their work is, after all, quite good." Frank was so delighted to learn of Irving's concise editorial tribute that he telephoned me from California to ask for a photocopy of the page with Irving's comments, presumably to frame it for his wall and to share with his students.

When a situation calls for criticism or outrage, Pitelka accelerates to heights that few can match in expressing indignation. One night after steak had been served in the Camp Dining Hall, Frank saw an unfamiliar young woman by the cages at the Animal Research Facility. She was taunting a wolf by making it lunge with bared teeth to get at steak bones through the cage mesh. Pitelka's pace quickened. "What's the matter *dear*," he hailed her as we approached, "don't wolves seem real to you unless you make them snarl and gnash their teeth?" Turning to me, he sputtered, "who *is* that *dish*, anyway?"

A year after that episode, I had just re-enacted it to entertain some newcomers to Pitelka's group, when Frank himself swept into the Dining Hall in his customary grand manner. To my acute embarrassment, Tom Custer tattled on me. "Hey, Frank, Dave here just did a pretty fair imitation of you." I was cornered, but my discomfort was short-lived. Pitelka nodded and chuckled appreciatively at hearing himself quoted. He then used us students as an opportune forum to explain his use of the word 'dear' on the wolf-taunter. "I find that calling a woman 'dear' is a sure-fire way to get her undivided attention. I swear, *any* woman *anywhere* will stop *anything* she is doing if addressed as 'dear' in an unfamiliar

man's voice." A few years earlier, during a visit to Italy, he had encountered a couple of Czech women, from whose conversation he understood to be disoriented and separated from their tour group. Stepping forth gallantly, he opened with the Czech equivalent of "See here, *dears*..." Pitelka portrayed his having frozen the women in their tracks so they would miss not a syllable of his Slavic eloquence. "Addressing them as 'dears' guaranteed me the rapt attentiveness of those two. Mind you, my tactic backfired. Their tour leader cut short my noble intentions by swooping in from Lord knows where, to herd my audience safely out of hearing range. It simply wouldn't do, you see, for innocent young Socialists to be corrupted by listening to someone from degenerate Capitalist society. The withering look the tour leader shot me over her shoulder indicated that merely speaking to them was an unspeakable indiscretion," he laughed.

Toward his own group at NARL, Pitelka could be just as protective as that tour leader. He once fretted lest I waste as much time as he had, trying to decipher some of the prolific and wordy Russian-language literature churned out by certain Soviet arctic ecologists. "Oh, Norton," he warned over a wagging finger, "you'll find some of those authors go on and on and on, with pathetically little to say. Honestly, sometimes I think that if I have to read one more page of that pap, I will absolutely have to puke—spelled *P-U-Q-U-E!*"

Pitelka's appetites are legendary. Steve MacLean and Tom Custer are always tickled by recalling the time at lunch when Tommy agreed to let Frank take a teaspoon sample of his dessert. Moments later, Custer spied his empty dessert dish and cried out,

"Doctor Pitelka, where's my dessert?" "Oh, *pshaw*," Frank downplayed his absent-minded larceny, "your choice of dessert was so good, I decided to eat the whole thing."

As his students warned me, Pitelka had a museum curator's covetous instincts. Upon learning that I had collected a specimen of a rare Eurasian shorebird on the tundra one day, Frank promptly tracked me down, to ask coyly, "May I put it up?" De-coded, Frank was seeking the privilege of preparing the specimen as a museum study skin, a skill at which he excelled. Beyond that, he avoided saying outright that he hoped to exercise the venerable doctrine that says possession is 90 percent of the law. His possession of this bird would stake his claim to the finished specimen for the Museum of Vertebrate Zoology in Berkeley. On the other hand, if I did not yield to his seniority, by retaining and preparing the specimen myself, it would naturally end up in the collections at the University of Alaska Museum. (This incident is typical of Pitelka's style. It takes a whole paragraph to explain the elaborate implications of his elegant 5-word question.)

Pitelka likewise coveted promising students and faculty in the manner of a collector. When one promising student strayed beyond the magnetic field that Frank hoped would draw that talent to Berkeley, Frank inquired and found that the student had chosen instead to study in Fairbanks. "University of Alaska?" he anguished. "Why not the University of *Vladivostok*, for pity's sake!"

His loyal disdain for institutions other than Berkeley notwithstanding, Frank admired a number of faculty and students at the University of Alaska of the 1970s. Once,

during a visit to the Fairbanks campus he caught sight of George West from across the parking lot at the Laurence Irving Building. “George, *Sweetheart!*,” he boomed in genuine delight, “how grand to see you.” The Physiologist blushed at the Ecologist’s enthusiasm, and scanned the surrounding campus to see who had been within earshot of the greeting. Dr. West may have been taking stock of campus associates to whom he would have to explain the antics of this distinguished visitor. But as we students had long known, Pitelka routinely expresses himself in ways that mere timid mortals dare not attempt.

Pitelka’s use of expletives and scatological language was extremely sparing, as if rationed for maximum effect. Early in our acquaintance the Professor was urging me to accept the offer of his personal assistance in the course of my upcoming research. Out of pure deference, I expressed hesitancy that I should deserve so generous a share of the great man’s time. Pitelka impatiently cut through my attempt to be polite. “Norton, what is your *bleeping* problem!?” Seeing my surprise at his expletive, he instantly shifted to a mock-solicitous tone. “Oh, pardon me: were you not brought up in the use of plain English?”

During IBP’s Tundra Biome studies, Frank Pitelka acted out his senior-advisor role with obvious relish. Peering over half-moon spectacles to conclude a Biome workshop session in the winter of 1971-72, he admonished his audience of investigators: “Populations of the brown lemming should peak in 1972. Think about witnessing a long-delayed peak in lemming numbers. Think about this peak with respect to the significance of these herbivores to nutrient cycling and,

hence, to tundra soil chemistry. Boys and girls, if we are gauging the ecological signals accurately, next summer at Barrow the lemmings’ *pee-pee* and *uh-uh* should keep us constantly running to our psychiatrists.”

Dr. Pitelka sometimes deliberately mocked the use of academic titles by addressing even the most junior students as “Doctor” so and so. The effect of this particular leveling device was to put us on our toes. It reminded us that Frank viewed himself as the team’s intellectual player-coach, and that in this capacity he expected nothing less than a high caliber of critical thinking from all of us, regardless of our stage of formal education.

Conversely, Pitelka occasionally delighted in holding up to ridicule someone else’s exquisitely nonsensical or obscure writing for his group at NARL. After reading aloud a selection with gestures of mounting alarm or pity for a befuddled author, Frank would remove his glasses so we could fully appreciate his facial expression, which might be anything: puzzlement, mourning, indignation, or merriment. If need be, he might nudge us to make comments with his own autopsy on a piece of gibberish by mimicking a favorite bit of ‘70s street slang. “I mean, come *off* it, man...”

Early in OCSEAP’s synthesis years Frank Pitelka (1979) organized and hosted a symposium at Asilomar on shorebirds in the Western Hemisphere’s marine environments. Pitelka peeked through a side door opening on a late-running afternoon session, where I was still listening to one of his invited speakers droning on. After pausing, dramatically silhouetted in the shaft of light he was

admitting to the darkened hall, the Conference Chairman crooked his finger at me, and stage-whispered: “Norton, come along: time for *drinky-poo*h.” Fully half the audience grasped his elaborately enunciated invitation as the leader’s impatience for the session to conclude. That, at least, was the proportion of listeners who stifled laughter, shook their heads, and exchanged knowing glances, as if to say, “there’s a fine example of the inimitable Pitelka for you.”

Dave Norton

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Dr. Takeshi Ohtake
Professor Emeritus, Univ. of Alaska Fairbanks

July 17, 1997

Dr. John J. Kelley
Institute of Marine Science
University of Alaska Fairbanks

Dear John:

I would like to congratulate the Barrow Arctic Science Consortium and the citizens of Barrow on the 50th anniversary of the NARL, now the UIC-NARL.

During the years 1967 to 1980, I visited NARL many times to work on my meteorological research and observations related to the Arctic Ocean and its vicinity. I would like to share a few memories of my visits to the NARL.

My first visit to NARL was August 1967. The purpose of my study was to measure air quality at Barrow, since we had a project to study Fairbanks Ice fog supported by the Environmental Protection Agency. I remember that Wien Airlines operated several twin-engine F-27 aircraft made in Holland to fly between Fairbanks and Barrow. We were picked up by a NARL truck with huge tires at Barrow Airport, and were welcomed by Max Brewer, John Schindler and many other staff at NARL. We met Frenchy and Nicole LeCloirec and Harry Brower at that time at the NARL. Memorable facilities included the fuel burning toilet system, Mess Hall, electric generator room, sauna, and GMCC.

The group from the Geophysical Institute at University of Alaska consisted of Takeshi Ohtake and Teizi Henmi. The Fairbanks Ice Fog Study supported by the U.S. EPA found that the Barrow air was very clean. Aitken Condensation Nuclei measured only 150 particles/cc, while in Fairbanks and other cities they measure more than 5000 particles/cc. I found Aitken condensation nucleus concentrations at Chena Hot Springs and South Pole were about 200 and 100, respectively. However, Glenn Shaw discovered that Arctic Haze occurred at Barrow in early spring every year about 10 years after our initial study. While flying back to Fairbanks we experienced very bumpy and cloudy air, resulting from a big rainstorm causing the Fairbanks Flood of 1967.

Although I have forgotten how many times and when we stayed at NARL, I clearly remember studies of clear sky ice crystal precipitation (so called Diamond Dust), in collaboration with Dr. Bjorn Holmgren from Uppsala, Sweden, Dr. Kenichi Sakurai from Asahikawa, Japan, and Dr. Kolf Jayaweera of Geophysical Institute. These studies were carried out using specially designed ground-operating, balloon-borne, kite-borne and airborne equipment. The conclusion of the studies is that the Arctic Diamond dust ice crystals from clear sky are formed by freezing of droplets steamed up from open leads of the Arctic Sea ice. The Atmospheric ice crystals over the Arctic Ocean region play very important role to climatic change studies. Our unique studies are presently considered to be excellent pioneering work, and the conclusions we made are still valid and currently leading the field. During the time of studies we enjoyed having Dr. Tadashi Tabata and Dr. Masaaki Aota from Hokkaido University, collaborated with Ron Metzner and Arne Hansen, Dr. Tom Gosink, Atsuko Ohtake my daughter and others at NARL, as well as Navy Commander Brian Shoemaker, who was Commander of U.S. Antarctic Base at McMurdo later.

We also made precise measurement of humidity in the leeward of open leads by use of a Finnish Vaisala hygrometer on a Twin Otter aircraft. We appreciated NARL's accommodation for us at the lab while we performed these studies. Bjorn Holmgren, Richard Siegrist, Kenichi Sakurai. Kolf Jayaweera worked with me. Ned and Sally Manning of NARL gave us much help, as well as National Weather Service (NWS) personnel at Barrow.

We hired an Aero-Commander aircraft from Colorado for the study, which was sponsored by atmospheric Science Section of NSF. The twin-engine airplane had sophisticated cloud physics equipment installed. When the airplane flew very low without its landing gear extended, I was afraid we would land with no wheels down. I shouted, "We don't have legs sticking out!" The plane aborted the landing and flew just above the runway as practice to scare me. I later told this story with a smile to Dr. John Kelley, Director of NARL.

We also photographed many beautiful rare sun halos, especially the perihelic circle and subhelic arcs. Dr. Kolf Jayaweera and I made studies of arctic stratus clouds. Dr. Gerd Wendler, Dr. Frank Eaton and I also studied artificial dissipation of summer arctic stratus clouds at Barrow, including seeding effects on arctic stratus and several studies on albedo and irradiance. In these studies, we used NARL aircraft and remember with pleasure our pilot, Lloyd Zimmerman, who was appreciated for his excellent and kindly services. We seeded clouds with silver iodide and/or liquid carbon dioxide to clear the thick summer arctic stratus cloud deck, which is slightly supercooled and blocks sunshine from reaching the Arctic coastal zone for long durations of the summer time even though the sun stays above horizon. We successfully cleared the clouds making "Barrow Air Canyon" aloft of Barrow and introduced sunshine to the city of Barrow for as long as 20 minutes, as shown in picture. Removed cloud droplets were changed to snowfall near the ground, as

officially reported by the Barrow NWS and observed by John and Eleanor Kelley and many other staff at the NARL.

These are but a few pleasant memories. We have appreciated all personnel at the NARL and congratulate the community on the 50th anniversary of the NARL.

Sincerely Yours

A handwritten signature in black ink that reads "Taku Ohtake". The signature is written in a cursive, flowing style.

Takeshi Ohtake

Professor of Physics, Emeritus at UAF

14250W. Warren Dr.

Lakewood, CO 80228-5937

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The Barrow Air Canyon, we created a large hole on thick stratus cloud deck over Barrow. The halos verify that water drop clouds in the canyon have changed to ice crystals clouds by seeding.



We brought "Sunshine" to the City of Barrow and vicinity for about 20 minutes on October 16, 1979. The picture was taken at 10:38ADT from 5300ft elevation. The sunshine zone has drifted to west of Barrow by east wind at this time.

Robert G. Paquette
 4032 El Bosque Dr.
 Pebble Beach, CA 93953
 May 8, 1997

This letter is written in response to John Kelley's request to Professor Bourke for reminiscences on the occasion of the fiftieth anniversary of the former Naval Arctic Research Laboratory (NARL). It is inevitable, I suppose, that the request comes after all the files are destroyed and many details depend upon my foggy memory.

My experiences at NARL are in two connections

- Five or so visits lasting two weeks each while teaching a Naval Postgraduate School course in Polar Oceanography at NARL.
- Short visits, usually of less than one day, when NARL provided a point of embarkation or disembarkation for the scientific crew of an icebreaker carrying out oceanographic observations in the nearby Arctic seas.

When I first arrived at the Naval Postgraduate School late in 1971, I think that the Polar Oceanography course had been taught at NARL twice, the second time by Warren Denner. I took over the course in 1973 and taught it for the next five years, using much of the structure that Warren Denner had built up and benefiting greatly in the first couple of years from the assistance of Jack Mellor. When Jack Mellor left NPS for the University of Alaska about 1974, Jerry Norton ably took his place.

It was a semi-structured course. The students got a fundamental grounding in the oceanography and associated sciences of the Arctic from my lectures and benefited greatly from the resident investigators who could be induced to lecture. Rita Homer I remember particularly as one I could rely upon to bring us up to date on oceanic biology in the arctic. There were geologists interested in permafrost, engineers interested in ice mechanics and strength (of increasing importance because of the drilling at Prudhoe Bay) and scientists interested in the whole gamut of problems associated with ice formation, ice thaw, heat exchange with the sun and atmosphere, ice drift and ice prediction. On our last visit I think the first of the LEAD experiments was being staged.

During the course, much of one weekend day was devoted to a "walk" (really more of a struggle) out to the edge of the land fast ice and a few hours to a flight over the ice in one of the NARL planes. We toured the animal pens, watched the huge polar bear grasp a proffered broom with a single enormous claw and could see in the wolves a larger, sturdier version of the playful dogs at home. Out on the tundra to see the wealth of flowers and the burrows of the lemmings, which we could also see caged in the laboratory, and marvel at the insulation against the arctic cold provided by a foot or two of snow and a few inches of tangled vegetation. Of course we visited Barrow to gain an appreciation of ordinary living conditions in the modern arctic. One year we saw a separately caged wolf that had been so well trained by a scientist on the

staff that he would spar with his trainer and behave like a German Shepherd of the lower forty-eight. This same staff member had built a useable but tiny igloo to bring back awareness of the days before white-man “civilization”.

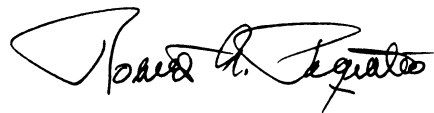
We had individuals among the students. One officer, addicted to running, would run the five miles north to Point Barrow every morning in below -20°F temperatures, successfully protecting his trachea from freezing by breathing through several layers of ski mask. During one of the last classes, “streaking” had come into vogue and one student was reported to have streaked through the winter night from the front entrance to the back entrance of the main building.

NARL treated us royally. All the facilities we needed and more: food, lodging, arctic clothing, logistics, lecture room, lecturers, library, scientific exhibits. All the requirements for a good course in arctic science given in the arctic environment.

My first contact with NARL was before the time of the new building when the icebreaker *Burton Island* made two oceanographic cruises across the southern Beaufort Sea in 1950 and 1951. I, then at the University of Washington, and John Lincoln accompanied Professor Clifford A. Barnes to make the Nansen-bottle observations. Except for the absence of the new building, NARL then was much the same as when I last saw it in 1977. But what a difference the new building made! My strongest memory of the old era is the sixteen-hole privy, heated somewhat within but not heated beneath. Thankfully, we were there in summer. The waste containers were the ubiquitous 55-gallon drums and, in those days of less attention to the environment, the entire privy, built into a large sledge, was periodically hauled far out onto the ice and the drums were jettisoned.

A brief mention of the other aspect of NARL’s contribution to my scientific work. During my years at NPS we made six oceanographic icebreaker cruises into the Chukchi and Beaufort Seas between 1972 and 1978. In several of these, NARL was the highly convenient point of embarkation and/or disembarkation. Then, as always, we received cheerful help: confirmation of plane tickets and transportation to the air terminal.

In conclusion, I must express compliments and gratitude to the Office of Naval Research and NARL, without which Arctic research in the United States would have had much greater difficulty in prospering.





Stanton H. Patty

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Photography

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9604 N.W. 28th Avenue

Vancouver, Washington 98665

May 17, 1997

Mr. John J. Kelley

The Arctic Institute of North America at UAF

P.O. Box 756808

Fairbanks, Alaska 99775-6808

Dear Mr. Kelley:

It is with great pleasure that I congratulate the Barrow community and the University of Alaska on the occasion of the 50th anniversary of the former Naval Arctic Research Laboratory.

My involvement with NARL was, to say the least, unusual. I visited the laboratory several times as the Alaska Editor of The Seattle Times — and as a son of the late Dr. Ernest N. Patty, a former president of the University of Alaska.

NARL was a fascinating place for a young newsman, with Arctic scientists pursuing research in a variety of disciplines. There never was a shortage of story material.

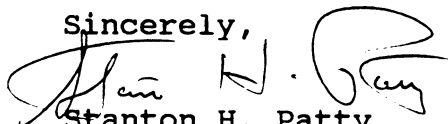
I have fond memories of interviews and field trips with Dr. Max Brewer, when he was NARL's director. Dr. Brewer would light his ever-present pipe and entertain this reporter with tales of the Arctic and Arctic legends such as Father Tom Cunningham.

Dr. Brewer also made it possible for me to visit the T-3 Ice Island research site for several days. The Times, of course, was eager to publish the stories from T-3. Fortunately, my editors never knew about the "agreement" between Dr. Brewer and myself to avoid writing about classified research being conducted on T-3. Perhaps those were the days of "kinder, gentler" journalism. I'd like to think so.

It was a privilege to be associated, as a guest journalist, with the scientists and staff of NARL – and to know the wonderful people of Barrow. The bond between the laboratory and Barrow transcends the usual – it is purely Alaskan.

I know my father, were he still with us, would be proud of this milestone in Arctic research. NARL was one of his priorities while serving as the University president.

Congratulations to all concerned. And thank you for allowing this reporter to be a part of NARL history.

Sincerely,

Stanton H. Patty

9604 N.W. 28th Ave.
Vancouver, WA 98665
Phone and Fax: 360-573-4367
e-mail: stanpatty@aol .com

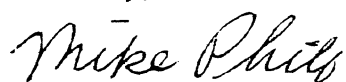
9439 Owl Way
Bozeman, MT 59718
29 July 1997

Dr. John Kelley
University of Alaska Fairbanks
Fairbanks, AK 99775

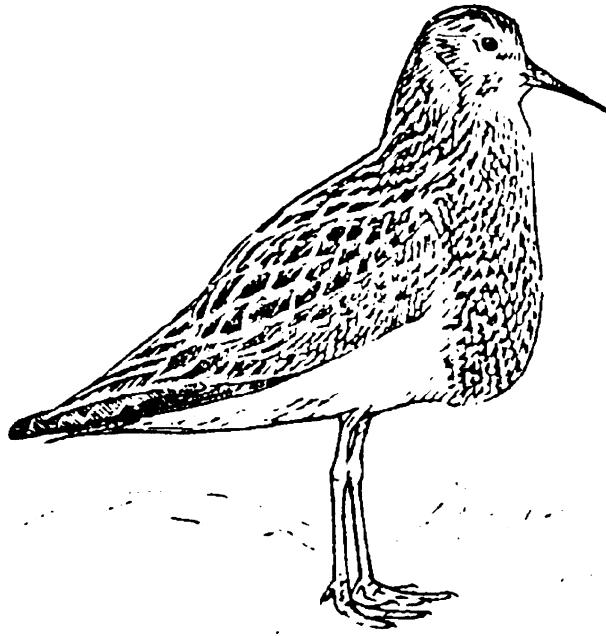
Dear John,

In thinking about the 4 1/2 years I spent at the Naval Arctic Research Laboratory, I realize that it had the greatest and longest lasting effect on my personal and professional life of any endeavor in which I participated. Many of my colleagues at NARL became lifelong friends - Dr. Art Callahan, Dr. Tom Albert, Dr. Erich Follmann, Ben Nageak, Craig George, Derek Craighead, to name just a few. I met my future wife and best friend, Barbara Jackson, at NARL in 1977. I remember work and life at NARL as one adventure after another and nothing has compared to it before or since. The in-house research program that Dr. Art Callahan developed at the Animal Research Facility was one of my most exciting and satisfying professional experiences. That program made possible the research project which became my Ph.D. dissertation. I left NARL in 1979, then returned in 1986 to work as a research biologist for the North Slope Borough. I found myself using the same facilities I used in the 1970s and working with many of the same people. I am now a regional epidemiologist for the USDA Animal and Plant Health Inspection Service. I have had a varied and exciting life and career; none of it would have happened if Art Callahan had not convinced me to transfer to NARL as the U.S. Army resident veterinarian in 1975. I appreciate the opportunity to participate in the 50th anniversary celebration and am very much looking forward to reminiscing and renewing old friendships.

Sincerely,

A handwritten signature in cursive script that reads "Mike Philo".

Michael Philo, V.M.D., Ph.D.



*Male pectoral sandpiper, sketched at Barrow by William D. Berry for
F. A. Pitelka.*

FRANK A. PITELKA
P.O. BOX 9278
BERKELEY, CA 94709-0278

8 May 1997

Dr. John J. Kelley
AINA - Rasmuson Library, POBox 756808
University of Alaska
Fairbanks, AK 99775-6808

Dear John --

Thank you for your letter 26 March re the NARL 50th. Two other NARI, associates beside you, by letter, plus two by phone, have asked if I'll attend. I wish I could. At my age (81), I have a set of body function problems that make long-distance air travel troublesome and risky. The only long-distance air travel I've done in the last few years has been within the coterminous states- e.g., to Tennessee two years ago last October to visit our second son, Wenz, at the Appalachian Center for Crafts, and last September to Frostburg to visit son Louis now at the University of Maryland.

To miss the NARL celebration and old friends gathered at Barrow is a real disappointment. I have many pleasant memories of working with a long succession of students over the 30 years of my program (51-80), with the lab administration staff, with native Eskimos who helped our field work in many ways, and of enjoying the company and camaraderie of resident and visiting scientists. And, of course, the tundra itself, the mountains, and the annual explosion of all the biological business on the tundra. My warmest greetings and best wishes to all gathered at NARL on August 27. I'll be thinking about you all.

Cheers,



Frank A. Pitelka

cc-MEBritton
SFMacleaen

Dear John,

Please excuse the handwritten note on this paper, but time & circumstances have been very limiting. I'm now doing Chaplain work in 2 hospitals & have four nursing homes & it keeps me hopping.

I certainly want to send along my congratulations to all concerned with NARL & the very important part it played in Barrow's history.

I was only a resident of Barrow for one year, 1965, & it was the experience of my life. I was pastor of the very small congregation of Catholics & also helped with the collection of City Sales Taxes so they could pay the policemen.

My congregation included some of the folks from NARL like the Schindler family & the highlight of my month would be an invitation to join them at the Lab for a dinner.

I always found it fascinating to hear of the various projects that were going on & just to talk with all the folks at the Lab. It was an "oasis" for a very isolated pastor.

Sincerely,
Fr. Jim Poole

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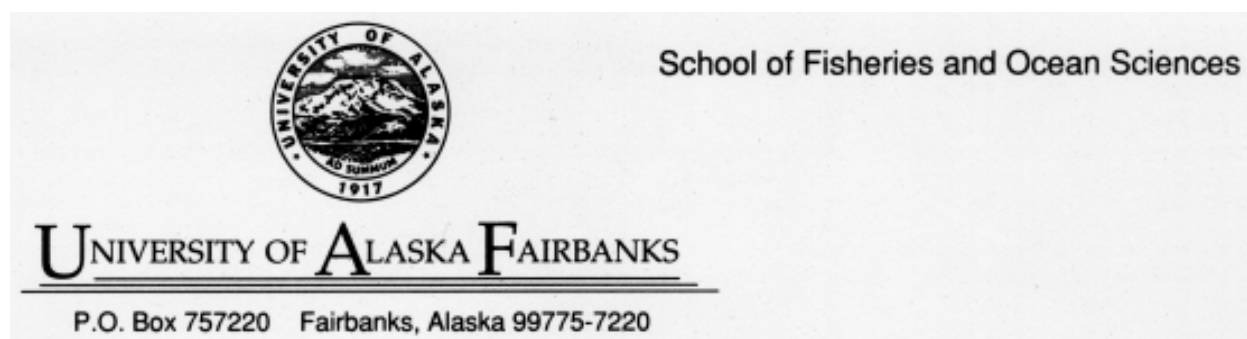
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Sincerely
Fr. Jim Poole”



St. Patrick's Church, Barrow, as it appeared in the mid-1960s.
Photo, courtesy of Father Jim Poole.]



June 1997

Happy 50th NARL!

It is an honor for me to contribute to the celebration of the 50th anniversary of the former Naval Arctic Research Laboratory (NARL). I first arrived at NARL in 1985 after it had been transferred from the U.S. Navy to the Ukpeagvik Iñupiat Corporation and was referred to as UIC-NARL. I worked for the North Slope Borough, Department of Wildlife Management as an acoustic technician on the Bowhead Whale Census project. Although most of my time was spent on the sea ice deploying and maintaining arrays of hydrophones to record bowhead vocalizations, the Arctic Research Facility (ARF) at UIC-NARL was the logistics base.

The ARF was a candy store for this young arctic scientist. Throughout the building and grounds was evidence of the studies that had been conducted there. On the wall was the genealogy of the captive wolf pack that was the object of study for some years at NARL. The shelves held many preserved specimens (including some bearing the names of the wolves on the chart). The polar bear cages were eerily quiet and frightening even though empty, but there were plenty of stories told about "Irish" who was at least one of the occupants. I imagined that at least some of them were true.

After the NARL Dining Hall was torn down, the dining room at ARF became the place for scientists and nonscientists from all over the world to share meals and ideas across disciplines and cultures. I have exchanged ideas with many outstanding people in that room including Robert Rausch, John Bockstoce, George Divoky, Bernd Wursig, Bernd Heinrich, John Wingfield, Lynne Dickson (Canada), Zhang Qingsong (China), Will Steiger (adventurer), Flip Niklin (photographer) to name a very few. I also had many great discussions with the many not-yet-famous dedicated technicians and field crews of the many projects that the North Slope Borough has encouraged, supported, and/or funded over the years. In the years when Ben Nageak was the Director of Wildlife, he would often visit the ARF in the morning, bursting in on our groggiest time of day and catching us by surprise with his overwhelming and loud, positive attitude and off-color humor. Before any of us could recover enough to even partially retaliate he would be gone. I have always enjoyed knowing that Ben's introduction to science was catching lemmings for the scientists at NARL. I hear the going rate then was a dollar per lemming.

I returned each spring to work on the Whale Census through 1988. The Whale Census project allowed me to observe and participate in spring subsistence whaling activities. I have many fond memories of snowmachine rides to whaling camps to help pull in the whales, take measurements and collect samples. My first trip to a successful whaling camp was double on a snowmachine with Charlie Brower. Most of the snow had melted, taking away any cushion the trail across the sea ice may have had. We tipped the snowmachine over no less than four times in the rough ice to get to that whale; however, the celebration of the whale was very much worth the bruises. Although whaling is not part of my culture, I was always welcome to help pull the whales onto the ice and to share *unalik* (fresh boiled maktak) with the others helping in the harvest. At the direction of the whaling captain, the whale was cut and distributed quickly, efficiently, and expertly by the crew. It was clear to me that I was experiencing an old and important cultural event.

From 1991-1996 I visited Barrow each summer as a U.S. Fish and Wildlife Service biologist studying migrating and nesting eiders in cooperative projects with the North Slope Borough, Department of Wildlife Management. Barrow is an incredible place for a scientist to work. Its latitude and position at the confluence of the Chukchi and Beaufort seas makes it a unique place for marine and terrestrial studies of all disciplines. But it is the people who live there and recognize its scientific importance that have made it the arctic science hub that it has become. Some of these people are Ben Nageak, Dr. Tom Albert, Charlie Brower, Harry Brower, Jr., Craig George, Marie Adams Carroll, Geoff Carroll, Robert Suydam, Warren Matumeak, and Raynita “Taqulik” Opie. The Iñupiat people of Barrow are gracious, sharing people who have taught me many things, and in doing so have made me a better scientist and a better person.

□

Quyanaq,



Lori Quakenbush
Research Associate
University of Alaska

Louis O. Quam

*9642 Burke Lake Road, Apt 201A
Surke, VA 22015*

MAY 22, 1997

Dr. John J. Kelley
The Arctic Institute of North America
Rasmuson Library, University of Alaska
P.O. Box 756808
Fairbanks, Alaska

Dear John

It is with great pleasure and just a touch of sadness that I respond to your invitation in behalf of the Arctic Institute of North America to write a letter of congratulations to Mayor Benjamin Nageak and all of the people of the North Slope Borough on the occasion of the celebration of the 50th anniversary of the former Naval Arctic Research Laboratory (NARL), now named the Ukpeagvik Iñupiat Corporation (UIC)-NARL Facility.

It is very pleasing to me to know my letter will be included among the assemblage of such letters you will bind and present, not only to Mayor Nageak, but also to the Bill Brower Memorial Science Library, which is a part of the UIC-NARL Facility, and to the University of Alaska Archives. It is good to know these testimonials will be part of the permanent record.

My life, as you know, was much intertwined with the history and operation of NARL and my working relationships with the Arctic Institute in sponsoring contract research at NARL, and elsewhere in the Arctic, were long, close, and highly valued. The touch of sadness referred to above is simply the consequence of knowing I cannot be with all of the celebrants and join in all of the activities I understand are being planned by the Barrow Arctic Research Consortium. I know many of my old friends and associates will be there and it would be so wonderful to enjoy reunion with them and to meet new friends. If only my health were just a little bit better, I would be so happy to be with you. My thoughts will happily be with all of you during the meetings to take place in Barrow during the period August 4-8, 1997. It is my wish that all of the Natives of the North Slope, especially the few that I knew such as Pete Sovalik, Chester Lampe and Kenny Toovak, as well as all others who served NARL so loyally and well over the years, know they have my complete respect and admiration for their contributions to research as well as to the safety and well being of the investigators who came to the Laboratory.

I share in what must be enormous, justifiable pride on the part of the local people in having not only acquired NARL when the Navy decided it must cease its operation, but to have maintained it so well in the continuation of research and research support. Especially, it is pleasing to me to

acknowledge that Ilisagvik College shares in the use of the total NARL facilities and is contributing importantly to the lives of the local people. This is truly a remarkable record of achievement and I wish all success to the citizens who have made these accomplishments possible.

I first visited Barrow and what we then called the Arctic Research Laboratory (ARL) in 1950 when, as the Head of the Geography Branch, Earth Sciences Division of the Office of Naval Research, I was investigating whether we should assume the management and financial support of the Arctic Program, which included the Laboratory. Its origin and history to that time had been vested in the Biological Sciences Division of ONR, more specifically in the Environmental Biology Branch, but at this time, after only a little more than three years of operation, consideration was being given to finding another administrative channel to take over the entire Arctic Program or to abandon it.

I was enthusiastic about bringing ARL under the Geography Branch program where the breadth and scope of research supported was quite in line with the diversity of sciences which should be supported at ARL. In fact, a considerable variety of research in the physical sciences had already been conducted there under the management of ONR biologists.

Dr. Ira L. Wiggins of Stanford University was Scientific Director of ARL at the time of my visit and gave me every assistance in gaining appreciation of the merit of the programs in progress and the need for continuing research. People conducting research there at the time were some of the best known among the NARL fraternity and some of these, Dr. Robert Rausch, for example, I understand are still active arctic researchers after all these years. Based both upon my firsthand assessment and the excellent advice I obtained from many knowledgeable scientists, both within the Arctic Institute of North America and elsewhere. I elected to take over the responsibility for ARL's future, and funding for the entire Arctic Program, this change becoming effective in the following year, 1951.

I am mindful of the fact this was also the year that an outstanding, young U.S. Geological Survey employee, Max C. Brewer, arrived at NARL. He was destined to have large impact on science and support of science there in future years, although this was unknown to us all at the time. It was in the following year that I became acquainted with Max E. Britton of Northwestern University who also was to have then unanticipated influence on NARL and arctic research in general. Then, in 1951, he was getting geared up, under Arctic Program support, to conduct ecological studies at Barrow. These studies began in 1952 and brought the lives of Britton and Brewer into the same orbit. Although Brewer was away working in his home office during the early part of that summer, once he returned the two men quickly developed close friendship and mutual regard which were to have broad implications on the future of NARL.

By 1954 the program was growing rapidly, I realized I needed help with its administration, and I sought someone to become Scientific Officer for the Arctic Program. Briefly, I recruited Max Britton for the position and he joined my office in the autumn of 1955. Having worked at NARL, he had many views of things needed to improve and expand its functions. One of the most critical of these, as I recall, was his perceived urgent need for a full-time, resident Director.

In 1956 the opportunity arose to select such a Director and Britton was ready. He named Brewer as his choice and convinced me of the merits of the appointment. This created a delicate situation because the University of Alaska was by this time the contractor for the logistics operation of NARL and had the prerogative to select and name its own contract personnel. Dr. Ernest Patty, then President of the University of Alaska, came to our office in Washington, D.C. with well-prepared arguments for his right to name his own personnel for a University of Alaska contract. He actually had a faculty member in mind for the Directorship and argued quite reasonably that, even if he had not, it was his right and responsibility to seek his staff wherever he wished and by his own criteria.

Discussions were gentlemanly and thoroughgoing; somewhat handicapped by the fact President Patty did not know Max Brewer or anything about his qualifications. Ultimately Dr. Patty became convinced of the importance of Britton's absolute requirement for a Director who not only would share his goals but would be one with whom he could be assured of very close and amiable working relationships and complete mutual confidence. Dr. Patty had several concerns which were satisfactorily resolved. Of special concern was his demand for assurance that the new Director would faithfully represent the University of Alaska, not just us personally and ONR. Max Brewer found this requirement understandable and agreeable and throughout his unexpectedly long tenure at NARL as a University of Alaska employee. I believe he steered a steady and evenhanded course between the interests of both parties to the contract and their representatives.

Brewer accepted his appointment on May 3, 1956 and assumed his duties in Barrow in September. From this time forward the two Maxes developed an easy and friendly management style which served ONR scientific goals, as well as the functions assigned to NARL, in an outstanding way. Mutually understood positions with respect to the problems of one in Washington, and those of the other in the field where the work had to get done, permitted gratifying growth in diverse and closely coordinated research programs. There were many innovations, including improvement of all support facilities. High on the agenda was the improvement in the tools and methods of accomplishing research both on land and at sea. With the cooperation of the investigators themselves and the help of many Natives as advisors and partners, many innovative means of accomplishing research were perfected. These, coupled with the development of a fleet of small and medium aircraft, allowed a long-delayed extension of research far into the Arctic Basin on floating ice stations. Now Navy marine research was no


longer essentially confined to nearshore, ice-free waters of summer.

Although I shortly (1959) became Director of the Earth Sciences Division of ONR and Max Britton became fully in charge of the Arctic Program, I retained my enthusiasm for the Arctic Program which I had taken on and kept alive in some difficult times. I was always ready to lend the force of my office to the accomplishment of the general program goals as well as the specific needs of NARL. Especially, I recall ways in which I was instrumental up the chain of command in advancing larger projects entailing the need for new and additional resources. These included, among others, such features as the fleet of aircraft mentioned above, and an aircraft hangar.

In 1967 I moved to the National Science Foundation but before leaving ONR had initiated procedures which assured construction of new NARL facilities. In 1969 the resulting modern laboratory and living quarters were in use and dedication ceremonies were held. I was happy these improvements then served Navy objectives so well for more than a decade and now do the same for those of the Natives of the North Slope. I take pride in my role and I want to be remembered for it. Such letters as this, which you have invited will assure long record of our memories. I understand the two Maxes will be present for the celebration and I shall ask them to represent me. You too, John, longtime investigator and last Director of NARL for ONR, will give me honored representation. I shall be pleased too to be remembered by John Schindler who served Max Brewer, therefore us all, loyally and ably for so many years as Assistant Director, then to become the first post-Brewer Director after he departed in 1970.

With all best wishes to you, the Arctic Institute, and all of those remarkable Iñupiat people who are making the celebration possible.

Sincerely,

A handwritten signature in cursive script that reads "Louis O. Quam". The signature is written in dark ink and is positioned below the word "Sincerely,".

L.O. Quam

□

April 30, 1997
Dr. John J. Kelley
Coordinator, Barrow Letters
% Institute of Marine Science
University of Alaska - Fairbanks
Fairbanks, Alaska 99775

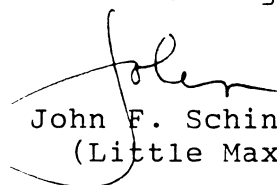
Dear John:

When you presented the idea of creating a collection of personal letters to present to the people of Barrow, I was pleased with the opportunity to express my gratitude. I have since spent much time thinking about what to say and whom to thank.

I first went to Barrow in the spring of 1960 and stayed until Christmas of 1973; from researcher to laboratory staff member. I have to admit that I was terribly naive and knew more about how to get around the big city of Chicago than any parts of the tundra. I guess I was a typical greenhorn, eager but ignorant. I especially remember how tolerant and patient people were of my unknowing ways. I am reminded of how often I would suggest that something be done and the response was simply a "maybe" or a nod, with no movement except to shift from one foot to the other. I finally learned to keep talking and explaining until I got it right. Then I would get a smile and things would happen. In this gentle, face saving way, people taught me what one could and could not do in the Arctic.

When I think back to all the people I wish to thank, I realize that I cannot single out any one person or persons - although many were outstanding - because to do so would leave out many, many others. I simply want to say thank you to everyone. Thank you for your knowledge, your patience, your kindnesses, and especially thank you for your friendship. I cannot think of Barrow without a lot of warm and wonderful memories.

With warm regards,


John F. Schindler
(Little Max)

2473 Captain Cook Drive
Anchorage, AK 99517-1254

Capt. Brian Shoemaker, USN (Ret)
348 Sunlake Dr.
Lakeside, OR 97449

Dr. John Kelley
Project Coordinator
Arctic Institute of North America
Fairbanks, AK 99775

Dear Dr. Kelley

It gives me great pleasure to advise you on how Dr. Max Britton influenced my life, my naval career and the future of the Navy in the Arctic regions.

In 1969 when I entered the Naval Postgraduate School in Monterey, California to study oceanography, I approached Dr. Warren Denner and asked him if I could conduct a research project in the Arctic Ocean for my thesis research. I had recently returned from the Antarctic where I served as a science support pilot for two years and, although I didn't know it, I was the first student at Monterey to ask to do research in the Arctic Ocean. Dr. Denner promised to help, but said that it would take money - he turned to Max Britton at the Office of Naval Research who saw merit in the project and granted the funds to make it happen.

The following spring Dr. Denner and I arrived at NARL and we met with Dr. Max Brewer and two hours later I was aboard an R4D with Dick Dickerson on the way to ARLIS V. The camp was just being built and I was to serve as radio operator. It was a wonderful experience - a learning experience and I became a fan of doing field research from floating "ships of ice" and learned that you cannot do this kind of research without Eskimo field support. Once the station was built, Dr. Denner accompanied a number of other scientists to the site and we began to gather research data.

While we were on ARLIS V we came up with the concept for conducting a two-week field seminar for all Naval Postgraduate School students at NARL. We went back to Monterey and put in for a grant and again Max Britton

supported that concept. As a result for the next 10 years the Naval Postgraduate School graduate oceanographers cut their teeth in the Arctic as students at NARL - men who became leaders throughout the Navy including submarine skippers who sailed their ships under the Arctic Ice pack. Today, Admiral Paul Gaffney, Chief of Naval Research, can be counted as a proud graduate of this program.

Because of my background at ARLIS V and later on T-3 under the tutelage of Charlie Hopson, I was selected as Commanding Officer of NARL and served from 1974 to 1975. I had the honor of serving at a very momentous time - during the establishment of the field camps of Operation AIDJEX. The training and experience in the field as a researcher authorized by Max Britton served me well.

Later after a couple of tours in the fleet and because of my experience in the Arctic, I was selected to become the Commander of Operation Deep Freeze in Antarctica. I spent three years in the South Polar Region in this position. Later when I retired from the Navy, I was asked by the British to spend a sabbatical at the Scott Polar Research Institute at the University of Cambridge. Upon finishing this phase of my life, I was asked to serve as the Secretary of the American Polar Society an organization formed by Admiral Byrd, Lincoln Ellsworth and other great explorers - I serve in this position today.

Looking back at the watershed moments that shaped my life, I have to focus on the understanding that Max Britton had of the importance of training young Naval Officers in things Arctic and the awarding of a grant to me to study there. The rest is history and I am deeply indebted.

Thank you Max!!
Very respectfully

Brian Shoemaker

2343 Judson Street
Longmont, Co 80501
9 July 1997

The Arctic Institute of North America
Rasmuson Library
P.O. Box 756808
University of Alaska
Fairbanks, Alaska 99775-6808

Dear Sirs:

My heartiest congratulations on the 50th anniversary of the founding of the Naval Arctic Research Laboratory. I am pleased and proud to have been part of its history and to have participated in its activities.

I arrived at the then Arctic Research Laboratory in June of 1959 as an assistant to Stanwyn G. Shetler, now Curator Emeritus (Botanist), National Museum of Natural History, the Smithsonian Institute. We were collecting specimens of the blue bells complex (Campanulaceae, Campanula sp.) throughout Alaska for Stan's doctoral research. I spent some time on the Meade River with William Maher while Stan collected other localities.

At the end of the summer, having obtained a Master's degree in biology at the University of Michigan, I still had not found a job. Luckily a position opened at ARL. For a few months, I worked as the Lab's secretary until Eileen Ray came to the Arctic from Colorado to become the bride of John Workman, a technician, and took over the position. I then became a scientific technician for Max Brewer, Director, working on soil samples, growing plants in the greenhouse, and checking ground temperature recorders in the field. In the fall of 1960, I became an administrative assistant in charge of shipping and receiving, and finally returned to work on a doctoral degree in Entomology at the University of Florida in the fall of 1962.

During my tenure as administrative assistant, ARL was receiving various kinds of merchandise without invoices from vendors in Fairbanks, Anchorage, and Seattle. This strange procedure made it difficult to conduct business on a timely basis. To remedy the problem, I composed a letter stating there was a statute of limitations for payment of bills. After a specified time, no payment could be made. Aside from disturbing the University of Alaska's comptroller, who received several frantic calls, the ploy worked very effectively, and my paperwork was soon flowing smoothly.

During the summers of 1960 and 1961, I was privileged to be the field assistant of Dr. Eric Hultén of Sweden, recognized as an international authority on circumpolar plants. He generously identified and returned my extensive collection of pressed plants, collected with his learned advice, which was later deposited in various U.S. herbaria. Dr. Philip Johnson of Dartmouth University arranged to have labels printed based on my field notes, and Hultén's identifications typed for the collection in exchange for the first set of specimens. The University of Florida, in exchange for a set, kindly shipped other sets to CRREL, the Rocky Mountain Herbarium, and the herbaria of Alaska and Iowa State Universities, in addition to a set deposited at Arctic Research Laboratory. Max Brewer, then Director of ARL, kindly made all this possible by allowing me to ship the collection to the University of Florida when I returned to college, where the herbarium curator, Dr. Daniel Ward, a member of my doctoral committee, housed the collection until it was labeled, sorted, and shipped to the above locations. The only portion of the collection that Dr. Hultén did not return was from Umiat, since his own collection from there was lost in transit to Sweden.

During my time at ARL I met many scientists engaged in various research projects, all of which created a very stimulating work environment. In later years, I deposited a collection of spiders, obtained during my travels across the North Slope, the Brooks Range, the Yukon, and Northwest Territories in the American Museum of Natural History in New York. ARL generously furnished supplies and support for this field work. I am greatly indebted to Max C. Brewer, John F. Schindler and to the skills of pilots Bob Main, the late Bobby Fischer, and Bob [= Lloyd] Zimmerman who made my stay at ARL a very productive period of my life.

Again, congratulations on the 50th anniversary. I only wish I could be there to celebrate with all of you and meet once more with old friends.

Sincerely,

A handwritten signature in cursive script, reading "Karl J. Stone". The signature is fluid and elegant, with the first name "Karl" being more prominent than the last name "Stone".

Karl J. Stone, PhD
Genealogist

MEMORIES

Contributed by Karl J. Stone

I remember Arctic Alaska as a fascinating area of contradictions. Its people were generous and kind, looking forward to improving their lives and providing opportunities for the children. Although there was a primitiveness evident in the forms of litter, rusting oil barrels, and yellow ice, signs of progress were there in the school, dress, and the merchandise shipped in from catalog shopping.

When I visited the Colville River Delta, where various plants reach their furthest northern distribution due to the river system, a vacuum cleaner came along with us from Sears. There was no electricity at the outpost, but that was no concern. We were served a delicious orange cake for dessert, another surprise.

In Barrow, if someone wrote a check, it was handled as legal tender, passed from person to person and signed accordingly. Woe betide the last person who tried to cash it at a bank in Fairbanks or elsewhere. Some signature would have faded or been worn away as the document was folded and refolded. There was no bank in Barrow until around 1961 to ease the problem. Uniquely located next to a junkyard? it was a wooden wanigan, a temptation to an enterprising thief with a caterpillar tractor, to rob the bank holistically. (But where would they go with it?)

I hoped to locate some baleen, the long, fringed sheets that line a whale's mouth. I asked a native if there was any for sale somewhere and was told he could get me some for five dollars. I declined the offer and went down to the shore that bordered Barrow. There I found several large pieces which are now on display in my home in Colorado. Later I was lucky enough to purchase two baskets made of the material, each labeled with the maker's name. Years later, I found a publication that told about these pieces of art and discovered I had two treasures, as the making of these baskets is a dying art. Someone found a large fishing net made of the material in a lake near Umiat, a rare find indeed.

One of my most powerful memories of the Arctic was the beauty of silence in a vast landscape. An approaching plane could be heard from miles away, the only form of noise pollution I encountered, except for a generator at Anuktuvuk Pass, and the sound of outboard motors on the umiaks during whale hunting season. When I returned to the south forty-eight, I became more appreciative of that rare experience I had amidst the vastness of the tundra. I still miss it to this day.

When a plane went down, rescue workers in planes appeared from everywhere to join in the search. It gave one a feeling of security to know help would be on the way

as soon as the alert was broadcast. One such incident permanently changed procedures at ARL. Max Brewer and John Schindler, Director and Assistant Director of ARL, respectively, had flown on the same flight to one of the Arlis stations located in the Arctic Ocean. It was the close of the summer season and the dark period was not far off. A new group of scientists was put on the island and the group that had been stationed there for a few months was to come home. A whole season's worth of data would come with them. Somehow in the dark, the plane was refueled with the wrong fuel. Shortly after takeoff, an engine quit and the pilot tried to return to the island, switching fuel tanks in the process, which sealed the plane's doom. As the second and final engine began to sputter, the plane lost altitude. Just ahead loomed a large jagged ice ridge formed by two massive sheets of ice grinding against each other. As the disabled plane barely cleared the menacing ice, a large smooth area spread out in front of it. It landed safely, and within forty hours everyone had been safely returned to ARL. In the meantime, when the message reached the Lab of the "crash," Otha Whitsett, the radio operator, was so upset he called Mary Lou Brewer, Max's wife, to ask where he was. The Lab was in a turmoil. At the time, I was in California checking on a job opportunity, and sent a telegram to the Lab about my activities, written in German as a joke. I later saw the result, a fractured mess of unintelligible Germanic scrabble. Shortly after the rescue, a plane returned to search for the downed aircraft to retrieve the valuable data that had been left behind, and hopefully repair the plane sufficiently to fly it back to ARL. Since the dark period had nearly started, very little light was available and that amount for a very short time. It was necessary for the search plane to fly low with its lights on, which was soon deemed too dangerous to continue. In the spring, the disabled plane was finally found, but an ice ridge had broken it into three parts and the retrieval plans were abandoned. After the crash, the Director and Assistant Director never flew together in the same plane again.

The Arctic cold was legendary, causing strange things to happen, like freezing mercury in thermographs, and preventing the lighting of kerosene stoves due to the lack of fumes. One research team arrived from California in a "Arctic-proofed" flying boat to study ice formations. On the initial research flight, a strange noise was heard in the plane shortly after takeoff. Quickly returning, the crew found the noise was caused by their aluminum antenna which had shrunk six inches. After numerous other problems, their mission was scrubbed and the crew was advised to return home. One of the mechanics was my roommate during their short stay. "Scotty" was on his last flight and planned to retire when he returned to California. When the plane left, Bob Main, one of the ARL pilots, was a passenger, but he decided to leave the crew in Fairbanks. He had dubbed the aircraft a death trap. His evaluation proved to be correct. On the way down the Canadian coast, the plane disappeared. It was finally found months later on one of the rugged islands bordering British Columbia.

Chuck Thomas, a Hispanic of prodigious beer-drinking capacity, was in charge of the supply room, sending supplies out to the scientific parties scattered across the Arctic Slope and in the Brooks Range. One time he had put insect repellent in with the meat and jam with the mail in an air-dropped shipment. Among other things, over time he had sent three air mattresses to Dr. Otto Geist, a grizzled, gruff professor who had taught at the University of Alaska for years. At the end of the season when Chuck was given a vacation trip out to the field, Otto insisted on being included in the supply team for Chuck's "expedition." On the first supply flight, Otto rode along to greet Chuck in the field from the air, a reversal of roles. He dropped the last item of the flight, the toilet paper, ripping open a package of individual sheets and throwing them out the window.

Chuck was a ladies' man in an environment with no single women. To compensate, he greatly enjoyed meeting the planes that arrived loaded with tourists coming to see the Arctic. The village kids soon caught on to his amorous glances and comments and brought them to a screeching halt. As ladies disembarked from the planes, the kids would run up to him enthusiastically yelling, "Hi, Daddy!"

One April Fool's Day, Lilly, the Swedish-French-Tahitian wife of a scientist, rushed into the main office to announce one of the wolverines was loose in the animal house. Max, realizing the gravity of such a situation immediately went to the door of the building to see what might be done. Slowly opening the door a crack, he saw the characteristic tan and brown fur of the animal through the slit, but it seemed elevated a bit too high off the floor. He discovered that Bruce, a beautiful husky dog and a camp mascot, had been shut in the building!

A group of botanists, three men and a wife, went out on an expedition to collect mosses and lichens. The flat tundra did not provide sufficient privacy for the wife when the need arose. The problem was solved by including a portable Christmas tree in the provisions.

When my teetotaling parents and sister came for a visit at Christmas time, they were invited to the numerous parties that were occurring. At the DEW line site, they unfortunately found the only available place to sit was in the bar section. A man with slurred speech informed my startled Mother that the lavish bar had been financed with the beer money. Later, at the Camp Superintendent's home, his wife asked my Father if he would like his glass refilled, and he politely said no. Surprised she asked what he had. "Seven-Up" was the reply. With a grimace, she blurted, "Dear God, no wonder!" Other than that, they had a wonderful time.

I was told the reason why the wooden cabs of the weasels, the tracked vehicles at ARL, had a hatch in the top. Each year scientists were warned not to venture out on the ice-covered lakes during the springtime. One unheeding scientist drove a weasel, which at that time had no hatch in the cab top, out onto lake ice. When he was found later, he had all but removed his splintered fingernails trying to escape from the vehicle which rested on the lake bottom with the ice located just at the top of the sliding windows on the cab sides. From that time on, all cabs tops were modified to provide escape hatches.

During coffee hour one day, Kenny Toovak glanced out the window and saw smoke billowing from under the eaves of the shop building. Everyone rushed out to find the building a total loss in a matter of minutes. No one was hurt, but the loss of equipment, shipped in from Seattle over the years, was staggering. Luckily some of the prefabricated sections of buildings, destined to be erected on the new Ice Island, were outside the building and far enough away to be rescued. The day after, all that was left was the scorched metal building with charred remains inside. It would take many months to replace the lost equipment so vital to running ARL. I have a free form piece of aluminum wrapped around charred wood as a memento of the disaster.

The shop foreman, known as "Father," was a mild looking man in his late 50's or early 60's. Newcomers were dutifully introduced to him with dignified deference. A short time after, Father would let loose with a stream of profanity that never failed to capture the new scientists' attention.

Within a few years after I left ARL, an article in *National Geographic Magazine* featured an underground house that was collapsed along the shore at Barrow around 500 years ago, presumably by a sheet of ice that was driven over the land like a huge and heavy knife. It was an example of the ongoing research that continued to make NARL a fascinating place to conduct research through the years. The current administration is to be commended for continuing to support a legacy of research. I wish the UIC-NARL success in the coming years, increasing the understanding of the Arctic, one of the remaining frontiers.

A REMARKABLE ESKIMO

Contributed by Karl J. Stone

Pete Sovalik was remarkable for several reasons. First of all, his very existence was unique, since he was half Indian, half Eskimo. The two native people were traditionally deadly enemies. As he explained to me, the Eskimo word for “Indian” is “Itkilik,” which means, “what goes in the mouth must come out the mouth.” That reportedly was what made them so mean.

Pete believed he was around sixty years old when I met him in 1959, a tall powerful man who had acted as a guide for many scientific expeditions throughout his life. Well known and respected among his own people, Pete served as a primary source of information dealing with many aspects of the Arctic, the environment, fauna, ethnic ways, folk history, etc. Though he had only a second grade education, Pete was a highly educated man, having vast knowledge about the Arctic.

One day a geologist from Louisiana was showing a map of the Colville River delta, completed after two summers of research in the area, to ARL Director Max Brewer and Assistant Director John Schindler. The Colville is the largest of the Arctic Rivers in Alaska, and had only been aerial photographed but not mapped. As the three closely examined the map, Pete, who was sweeping the library floor, came by. On an impulse, John asked Pete to look at the chart to see if he had any comments. Pete studied the document for a few moments, and then said, “There is a sandbar missing, right there,” and pointed to a spot. The scientist, somewhat taken aback, looked at the old aerial photograph taken during World War II days. Sure enough, there was the missing sand bar. John asked Pete when he had last been in the Colville Delta area. After a pause, Pete replied, “About twenty years.”

Pete had an uncanny ability to find his way around the tundra no matter what the season. One time I was assigned the duty of putting out baited live traps for lemmings during the winter. The white flat tundra stretched for miles before me, and I had no idea where a good place would be to catch a respectable number of the rodents, so I asked Pete for help. Off we went, trudging over hard packed snow for quite a distance from the Laboratory. He picked a place that could have been anywhere so far as I could tell. Several days later it was time to collect the catch. It took only a few steps before I was on a mission impossible. A fresh coating of snow covered the ground, obliterating any sign of our tracks made a week ago. Again, I asked Pete for help. Straight as an arrow, he led me to the correct area and found the traps in no time. My respect for his abilities reach even higher levels.

Another time, during the summer, some children from Barrow went out on the tundra and became lost. No one knew if they had taken food with them, and the search continued for two tense days before they were found. Afterwards, Pete was asked what he would have done if there were no planes or vehicles to assist in the search. Pete replied he would have sent them out again on the tundra after rescuing them no matter what their condition might be.

Pete's wife, Isa, was acknowledged to be the best seamstress in the Village. I decided to purchase a pair of mukluks from her, since their light weight was far superior to the oversized, heavy felt "bunny boots" we had been issued for winter wear. When I received the completed pair, I noticed the soles, made of harsh seal skin, appeared to have been crimped by biting them. Later I was told Isa had tried to use a metal crimper, but preferred to use her own teeth to do the job.

Pete knew I was interested in Eskimo artifacts, and went out of his way to find some unique ones for me. Among them was an Eskimo lamp, made out of a flat piece of copper which he said was from the plating of a shipwreck that occurred somewhere near Barrow years ago. He then brought out a pouch of crushed moss and a flask of seal oil. Carefully arranging the moss in a straight line along one edge of the large bean-shaped lamp with a spatula-shaped piece of copper, he poured in a bit of seal oil. Tipping the lamp sufficiently to make the oil flow into the moss, he lit the lamp and deftly arranged the moss to produce a uniform line of flame. When the fuel was gone, I asked to try my hand at the feat. I failed miserably.

Other artifacts he obtained for me included an ivory image of the legendary 10-legged bear, complete with incised fur, and a wooden scraper with finger grooves that fitted comfortably into my hand, smooth and just the right fit. In addition, he had an Eskimo drum made for me, a willow hoop with caribou hide stretched over it, and having a wooden handle. It was used at several Eskimo dances, struck beneath with a willow rod which slightly abraded the hoop, making the instrument more authentic. He spent time telling me how various arrowheads, blow holes, and sling weights were made and used, and had a miniature replica of a whale harpoon made for my expanding collection. I had purchased a woman's labret at "Gladys's," a store in Barrow that catered to the tourist trade. The labret, a flanged ornament pushed through a slit in the center of the lower lip, puzzled me since it was made of soapstone, none of which was within miles of Barrow. Pete theorized it was from a visiting woman who had been murdered.

When driving from ARL to Barrow during a spring day, I made it a point to smash the larger pieces of snow on the road. Light had returned to the Arctic and the road was clearly visible. A clump of snow came into view that looked a bit too big to hit so I made sure the jeep straddled it. However, just as I passed over it, I thought I saw two black spots suddenly appear. Looking back, there was a white fuzzy baby seal flopping along. This was a very unusual sight, as the ocean was many yards away. Besides, baby seals were either used as food, or the children used the frozen bodies as sleds for sliding down the low mounds around the village. I retraced my steps, captured the little fellow and took him on my rounds of scientific duties. When I returned to ARL, I gave the seal to Pete as an addition to the animal house. He was reportedly not enthusiastic about maintaining what should have been a fine meal, but he did his best. Unfortunately, the little fellow refused to eat. After several days, it was decided that the animal should be returned to the ocean. Pete took it out on the ice to an open spot and

put it in the water. Instead of swimming away, it remained still. He tried unsuccessfully to frighten it away, but left at day's end on the truck taking the workers to Barrow. When he returned the next day, the baby was gone, but there were sled tracks leading past the hole.

Later, another baby seal was found. Based on the experience of the first seal, Pete put this one into a sink of water before offering it frozen fish. It ate readily and thrived. At that time, a scientist was implanting wireless transmitters in the body cavities of various animals. A recorder at some distance would record the beating of the heart under various conditions, without a human in the sight of the animals. This was attempted with the little seal, but it rapidly developed an infection and died. It was a sad day at the Laboratory.

One of the perennial problems facing ARL was apprising visiting scientists of the dangers the Arctic could present. Because of this problem, Pete was often sent with scientific expeditions into the field with the understanding that his advice was to be sought and followed.

Arlis I (Arctic Research Laboratory Ice Island Station) was established on flow ice to conduct research in the Arctic Ocean environment. Prefabricated buildings were set up to house scientists and equipment, and a pole with the U.S. flag was erected in the middle of the camp. (Its supporting wires proved to be effective trippers for unwary personnel, especially during the dark period) Pete was among the personnel on the island when suddenly the ice cracked with a bang through the middle of camp. Instinctively he sensed the danger this posed to both men and equipment, and urged immediate action to safeguard personnel, equipment and data collected over several months of research. Later, while relating the incident, one scientist clearly indicated his lack of knowledge by laughing at Pete's concern. He was promptly informed of Pete's respected knowledge, and that he was probably still be alive due to Pete's prompt action. My time at ARL was greatly enriched by my friendship with Pete. He was indeed a remarkable man who taught me many things about his people and his beloved Arctic.

THE CRAZY MAN

Contributed by Karl J. Stone

Pete Sovalik told me this Eskimo tale.

Once there was a crazy man who had become a nuisance to his neighbors. To remedy the situation, the elders held a meeting and decided to give him a boat so he could take a trip. The men of the village quickly made the vessel and presented it to the delighted crazy man.

The very next day, he started on his trip, drifting down a nearby river. As he rounded a bend, he saw the reflection of a young Eskimo maiden combing her hair as she sat on a low hill next to the river. "I want that young woman," the crazy man said to himself. To capture her, he jumped into the river and swam around, but couldn't find her. He got back into his boat, and there was the girl, still smiling at him. Once again, the crazy man jumped into the river and swam around looking for the lovely maiden, but had no success. He crawled back into the boat, and there she was, still smiling at him. This happened several more times. Finally the crazy man thought and thought about this difficult problem. He decided she must be at the bottom of the river. So he paddled over to the shore to get a big rock. He tied one end of a rope around the rock and the other around his neck. He jumped back into the river with the rock, sank to the bottom, and drowned.

Pete said this was a story to explain the death of a man who had become a problem in a village.

CHESTER LAMPE
Contributed by Karl J. Stone

Whenever ARL invited the Eskimo workers to a party, there was always a cake with gobs of icing on it. This was a special treat for everyone, especially for Chester Lampe, who preferred to have the icing without the cake!

Many scientists came to ARL from around the States and from other countries. The fascination of the Arctic and the opportunity to do research there were the stuff of which memories are made. Cameras were always in evidence, though some presented unique problems, such as Polaroid models which had film that would easily freeze.

One scientist wanted to photograph the wolverines housed in the animal house. That would be a unique shot for the folks back home. He contacted Chester who fed them daily and determined the time of the feeding. Arriving early, the scientist carefully set up his camera and lights for the best possible angle to capture these powerful animals on film. Finally Chester arrived and began to push strips of meat into the cages to the hungry carnivores. Time passed and the scientist became anxious. "The wolverines are not coming out to eat," he exclaimed. "No," said Chester matter-of-factly, "they never come out when strangers are around."

DR ERIC HULTÉN
Contributed by Karl J. Stone

Dr. Eric Hultén of Sweden was one of the most eminent scientists to visit the Arctic Research Laboratory, a member of the Nobel Prize Committee and Swedish representative to the Russian Academy of Science among many other scholastic honors. He was also the head of the herbarium at the Museum of Natural History in Stockholm, the third largest herbarium in the world, founded by Linnaeus. Dr. Hultén came to ARL in the summers of 1960 and 1961 to examine the Alaskan Flora all across the North Slope and a few places in the Brooks Range. I was privileged to be sent along with him as a pair of sharper eyes and to assist the aging man as necessary.

Despite his august position, he was irrepressible. While conducting research at Anuktuvuk Pass, a geologist from Rutgers University, Dr. Fio Ugolini (who had recently legally changed his name from Boloni), was holding forth about his success with women before an enthralled audience of young Eskimo men, Dr. Hultén and I. As Fio carried on with increasing enthusiasm, I noticed Dr. Hultén rummaging around in a pack sac he had brought on the trip. Out came a large stick of deodorant which, with a few deft swipes, transmitted a softly scented aroma to an envelope which also was in the bag. Fio finished his tale, and while basking in the admiration of the audience, Dr. Hultén passed the envelope with its letter to him and stated he had just received a letter from the island of Capri, from his mistress who lived there the year around. Fio, astounded by such prowess of an elderly man, was dumbfounded, and the admiration in the tent switched to Dr. Hultén, who modestly accepted it as his due.

Dr. Hultén was relaxing in the men's lounge during a lull in research when the conversation turned to a perennial subject of interest. One person remarked about the free manner in which the Swedish conducted themselves in regards to sex. The dignified man snorted and replied, "Oh, we're not so bad. The way the English carry on, one would think they could scarcely procreate."

When he went to the local coffee shop in Barrow, Dr. Hultén found himself surrounded by Eskimos talking loudly in their native language. A collector of slang and idioms in whatever language, he asked me for a choice word or two of their language. I gave him two, only one of which I remember, "it-koo'-kee-chuck'." He told me that on his next visit to the coffee shop, he worked the word into conversation. The result electrified the crowd. The chattering stopped abruptly. Finally, the surrounding natives began to talk in lowered tones, apparently not knowing what else the man might have understood of their former conversations.

For years, the Eskimos related stories about icebergs having mounds of rocks and soil with living plants growing on them, but scientists dismissed such tales as mere folklore. In the early 1960's, during a reconnaissance flight looking for a new site for a floating scientific station in the Arctic Ocean, Arctic Research Laboratory personnel found a huge iceberg. And sure enough, there were piles of rocks with soil and living flowering plants growing on the mounds. Named Arlis II, the island soon held a series

of prefabricated buildings housing scientists and equipment. Dr. Hultén arranged to be on a flight to the island. He returned with a number of plants which were pressed and eventually shipped to Sweden, a loss to the United States of these historic botanical specimens.

It was rather exciting, in a concerned sort of way, to travel by plane with Dr. Hultén a few feet above the tundra, as he looked out the window and identified plants at several miles an hour. I tended to forget botanical matters as slight swells in the ground level loomed ahead of the plane. But the skill of the ARL pilots always saw us safely to our destinations.

Collecting plants with Dr. Hultén was especially exciting because he knew the plants so well and his comments indicated which were exceptional finds. Among the plants that were unusual was a grass typically found in Siberia, representing an extension of its range, and a ranunculaceous plant (distantly related to the buttercup) found in disturbed areas in China and a very few scattered locations in Asia. One memorable time we landed in a field of Rumex graminifolia, a plant he believed was only a paper species, described some years before by Polounin, a botanical rival of his. A paper species is a fictional species, described as a pastime by some botanists in an effort to insure their names as describers were engraved in science forever. This comment indicated the plant was poorly represented in botanical collections. I set to collecting as many as I could within the time allotted, despite his disapproval. He felt I would be flooding the herbaria of the world. The resulting 29 sheets of the plant, divided among five herbaria, were undoubtedly welcome trading stock!

While strolling down the beach at Point Hope, I came across a walrus skull with both tusks attached. I had told Dr. Hultén I hoped to find one washed up on the shore. He laughed at the preposterous idea, but changed his tune when I showed up with the skull. He wanted it to take back to Sweden. Since I wanted at least a tusk, I struck the massive bone with my hammer. He immediately offered to send me a Swedish “dolar” which he was certain was the origin of our word “dollar.” Due to his august position and the circumstances, I agreed. Some months later, a box of identified botanical specimens I had collected and shipped to Hultén arrived with a small paper box containing some old Swedish coins. After I removed the coins, the box still seemed heavy, but I threw it away with little thought that it might have a false bottom. Perhaps years from now an archeologist digging in the town dump will discover a fine silver coin to speculate about, perhaps from an early Swedish explorer!

Dr. Hultén’s stories of his life added another dimension to memorable field work. He had found an unknown volcano in Kamchatka, a peninsula in far eastern Russia, and nearly starved as the area had been devastated when the volcano had exploded few years before. Another time he nearly starved when the Japanese ship due to transport his party was delayed because of the Russian and Japanese War. That time he survived by strangling a marmot for a greasy meal. Collecting in Russia was hampered by the Civil War, forcing him to periodically wave a white flag as he passed

back and forth between the Bolshevik and White Russian lines. In the spring of 1961 he enjoyed some communal baths in Japan, following directions of what to do despite the language barrier. There was never a dull moment with the man. He was one example of the long list of eminent scientists that have done research at NARL.



Professor Hultén's entourage, mid 1950s: Left to Right, John J. Koranda, Dr. Harlow J. Hodgson, Prof. Eric Hultén, and Dr. Leslie Klebesadel. Photo, courtesy J. J. Koranda.

Mr. John J. Kelley
 AINA at UAF
 P.O. Box 756808

LOWELL THOMAS, JR.

Dear John:

I have your letter about the 50th anniversary of NARL and am happy to send along a few memories of times spent at the Lab while producing a film for the Univ. of Alaska during Dr. Wood's presidency.

This was in the 60's when the Lab at Barrow was known as ARL and was under the jurisdiction of the UofA, Fairbanks (there was no other branch of the university at that time, only a community college in Anchorage). The film was to be entitled "Look North" and was to focus on arctic research. In the spring of 1962 cameraman Bill Bacon and I flew out to ARLIS TWO, a scientific station on an ice island hundreds of miles north of Barrow. We flew in an R4D piloted by the late Bob Fischer, the first of a number of supply flights to be made. Bill and I expected to be on Arlis for about four days, plenty of time to film the scientific work going on, then we'd return on the next flight. However, the plane didn't return for nearly a month because of a bad engine that required a new one sent up from Texas; no UPS in those days.

My filming project was soon completed. Nothing for us to do but wait, speeding the depletion of rations at the station. We tried to be as helpful as possible to the crew and scientists, about ten in all I believe, one of whom was you, John, if memory serves. Arnie Hanson also was with you I think; and John Sater was station boss.

All the while the plane's engine was being replaced our ice island continued to drift farther north, almost beyond the reach of the plane. Back in Barrow, and in Washington, plans were being made to ask the Russians to evacuate us. That became a national news story. Fortunately, rescue by the Soviets wasn't necessary; Bob Fischer made it back just in time.

Those weeks on ARLIS TWO were memorable mainly as a rare opportunity to become familiar with the Arctic Ocean environment—the pack ice, ice islands, polar bears and fox. A few years later, this time doing a story for the National Geographic magazine, I flew my ski equipped Cessna 180, in company with Bob Fischer in ARL's 180, some two hundred miles to a landing on a floe station, Arlis Three, where Dr. Victor Hessler, of the University's Geophysical Institute, was studying the aurora and magnetic storms.

Although not a scientist, rather just a film maker and reporter, the Arctic Research Lab at Barrow, under the management of Dr. Max Brewer, was most helpful to me on many occasions. And I am pleased to send thoughts of gratitude, congratulations and best wishes on its 50th anniversary. May the next 50 be even more productive!

* Nov. '65 issue

Most Sincerely,

10800 Hideaway Lake Drive • Anchorage, Alaska 99516 • 907-346-3468



Remembrance Volume
50th Anniversary of the NARL
Barrow, Alaska

July 8, 1997

Dear colleagues and friends:

The relocation of my family, my laboratory, and me from the Great Plains in South Dakota to the North Slope of Alaska was really an annual migration between 1967 and 1975. This was a migration that was filled with anticipation, excitement, and, of course, some apprehension. I am indeed sorry that I cannot fit this summer's celebration into my work schedule. It would be a great opportunity to renew old acquaintances and review the changes that have occurred at "the lab," in Barrow, and even on the Coastal Plain.

I actually go back to the "old lab" which only some of you will remember. It was there where I first met some of the "early-timers" - Ed Folk, Curly Wohlshlag, John Kelley, Max Britton, etc. The list could go on for some time. However, some of the most memorable experiences involve the old greenhouse, never really operational except for some occasional *weed*, transplanted from California I am certain! As I recall, some of our students put a few of these in pots as seedlings and presented them as gifts to Max Brewer. Not really flowers!! Many of us will remember the waiting room in the old building, a room that was really a staging area for meetings with John and Max. With luck, after a wait of a few hours or a day or two, we would get in to see Max and in a minute would be on our way to some remote site on the North Slope. I have to say that I had unsurpassed logistics support my first year or two. In those days, when you had a small research grant from the ONR or the AINA, logistics came as a free fringe benefit. That was fantastic. It allowed me to see—and do field work—in a large number of fairly remote sites spread across the North Slope. We surely could not do that in the days of the IBP.

Some of us old-timers surely could not get together without a stream of bush pilot stories. Well, the NARL employed at least one infamous pilot who was never really under the control of Max. I think he basically flew where he wanted to, slept where it was convenient, always picked up a few mph by flying a few feet above the gravel ridge along the ocean, and often sent several of us closer to the earth than we ever wanted to be. Memorable was a trip he provided to Lake Peters. Upon arrival we got the radio working, after cleaning the field lab of about an inch of soot, and let the lab know that they had forgotten toilet paper in their provisions. I guess it was the next day, while I was in the boat fishing (I was really collecting grasses), when we heard this plane, saw it circle the lake and slowly but persistently throw out and unravel roll after roll of toilet paper!! Max and the pilot got us again!

The new laboratory was fantastic. Again an ONR grant allowed me to do some photosynthesis work; and this fellow, whom I would come to know well, saw the gear and popped into the lab to see what was going on. That was Jerry Brown and the start of a long relationship that led to a very successful Tundra Biome project of the USIBP. We have to thank Jerry for serving as the driving force behind the project, for giving us all the assurance that he would get the funding from the oil companies, that the logistics would be provided, that we could be assured of a long-term program, etc. He also saw to it that

we had adequate beer to lubricate the weekly scientific meeting I was insistent we have. Of course this meant that one room in my “house” was piled high with the annual IBP supply. Thanks, Jerry. Don’t tell us where the money came from. Barrow was the right place for us, NARL was the right laboratory, and Jerry was the right person. I also have to thank all the scientists at Barrow, where I was Site Director, and especially all the plant people. I am proud of the work the group did. I am especially happy with the very large impact our program has had on science both by pushing the edge all the time and by providing a lot of leaders in the field of ecology. We did a good job of populating the field. And I’ll never forget hearing a talk by Don Schell on stable isotope interpretations of carbon resources for marine animals. Although I pioneered much of the isotope work in ecology and archeology, I did not see clear applications in the tundra. After all, all plants were C3 types! Don and associates have shown otherwise and made very real contributions.

Some of you may be interested in the “underground archives” of those IBP days. I have forwarded to Jerry and a few others copies of *“Summer of ’72”* and the *Read Miver Enquirer*. These student spoofs were given to me after a couple of the field seasons and do capture some of the color of the projects! After 20 and 25 years, these documentary publications reveal insights to the old project and people! If you want an irreverent, occasionally risqué, and politically incorrect record of someone from those days, send me an e-mail.

The lab could not have functioned without the support provided by John Beck’s crew and others who kept the lab, wanigans, man-hauls, and tracked vehicles “going.” In fact, I still have in my lab boxes made the “Barrow way” with Tieszen and NARL stenciled all over the outside.

My family and I really appreciated Barrow and the Site. Some of the best experiences have been on the frozen tundra in early spring (mid-May) when few other scientists were there, when the snow still covered all the disruptions we and others made to the tundra surface, when birds were beginning to arrive, and the sun was nearly at its maximum. Few places have provided a similar “oneness” with nature. Barrow was a great experience for many of us. My children experienced the celebrations of whale catches first hand, we observed the polar bear attack one of the lab workers, we scoured the beach for artifacts and rode the man-haul into Barrow with the school children and workers.

Barrow and the lab must be a different place today. I hope some of the good times the scientists had with the people from Barrow still occur and that the serenity of the spring thaw still exists. My best to all of you.

Sincerely,

Larry L. Tieszen
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USGS FAIRBANKS

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United States Department of the Interior

U.S. GEOLOGICAL SURVEY

July 22, 1997

College International Geophysical Observatory
800 Yukon Drive
Fairbanks, Alaska 99775

Dr. John J. Kelley
Coordinator
50th Anniversary of the NARL

Dear John:

The celebration of the 50th Anniversary of the NARL brings back many very fine memories for me, one of them being the opportunity to work with you when you were the Director. I will always remember the good support and advocacy you showed for the Barrow Magnetic and Seismic Programs.

I write this letter because I have been associated with science programs at Barrow from the beginning of the Barrow Observatory which we started operations in 1949 when I was in Washington, D.C. with the old U.S. Coast and Geodetic Survey to the present time in my capacity as chief of the College International Geophysical Observatory. Today the Barrow Observatory is a very important location for geomagnetic and seismic studies and I am very pleased that out of my more than 54 years in my profession, 48 of them have been associated with the studies at Barrow.

As a little memento I am attaching a short report I made in June 1986 on the, "Barrow Observatory History, Mission, and Land Usage

My best wishes go to the wonderful people at Barrow, the University, and all who made contributions to the scientific programs at Barrow over the past 50 years.

Sincerely yours,

Jack B. Townshend, Chief
College International Geophysical Observatory

Enclosure

Barrow Observatory History

In 1949 in cooperation with the Navy, the U.S. Coast and Geodetic Survey constructed and started operating a Magnetic Observatory at Barrow on property controlled by NARL on the Naval Petroleum Reserve, near the village of Browerville, about three miles west of the NARL facility. The Barrow Observatory for administrative, technical support and supervision purposes was made a satellite station of the College Observatory at Fairbanks. In 1957 additional facilities for the observatory's operations were constructed east of NARL, and south of the DEW Line Site "POW-MAIN." In 1975 the facilities near Browerville were moved to the site south of DEW and all of the Observatory's operations were consolidated there. In addition, In May 1975 the Barrow Observatory was changed from a manned to an un-manned facility visited about every seven weeks by personnel from College Observatory to service the equipment. In the meantime the authority for operating the College and Barrow Observatories was transferred from the NOAA in the Department of Commerce to the USGS in the Department of the Interior. This became effective in September 1973.

In September 1964 a Seismic Vault was constructed twenty feet deep in the permafrost and a seismograph was installed. At the present time a seismograph is being operated there in cooperation with the Geophysical Institute of the University of Alaska at Fairbanks (UAF).

Since May 1975 the NOAA-GMCC personnel have assisted the operation of the Barrow Observatory by checking the equipment about once a week and whenever there is an emergency or breakdown. This has been most helpful to the USGS and contributed significantly to the successful operation of the un-manned station. NOAA began their GMCC operation with assigned personnel at Barrow in January 1973. The NOAA-GMCC Station is located approximately one-quarter mile east of the Observatory facilities.

Barrow Observatory General Mission

The Barrow Observatory's administrative and technical operation authority is through the Branch of Global Seismology and Geomagnetism of the U.S. Geological Survey in Denver, Colorado. The routine operational supervision is done by the College Observatory at the University of Alaska in Fairbanks.

The general mission of the Observatory is to produce comprehensive

data in the field of geomagnetism and seismology and to cooperate with other scientists and organizations within the capabilities of the personnel and facilities. The Observatory is operating a three-component fluxgate magnetometer recording Declination, Vertical and Horizontal components of the field and a proton magnetometer recording the total field. Data is recorded in digital form on magnetic tape and on analog chart paper at the site. The data is also transmitted by satellite to the Space Environmental laboratory of NOAA in Boulder, Colorado.

In addition a seismograph and magnetograph project are being conducted at the Observatory by the Geophysical Institute of the University of Alaska at Fairbanks.

Land Usage and Status

The land that both the NOAA and USGS facilities are located on was part of the NARL Reserve south of the DEW Site, POW-MAIN. We had permission from the Navy to use these sites. Since the Navy was declaring this property surplus to their needs, in 1984 the federal government agencies on Barrow Naval Reserve Property applied to BLM for a land withdrawal for the property that was needed for each operation. The withdrawal requests are presently under review by BLM and BLM has set this land aside, designated for each agency's respective use, pending final approval of the withdrawal applications. If it is necessary for anyone to check on the status of the land, the following are BLM Case File Numbers that can be checked at their Anchorage Office:

Air Force-DEW	Case File Number F-81645
NOAA-GMCC	Case File Number F-81469
USCG-Communications	Case File Number F-81470
USGS-Observatory	Case File Number F-81490

PLEASANT EXPERIENCES DURING VISITS TO THE NORTH SLOPE
BETWEEN 1957 AND 1996

H. JESSE WALKER
Louisiana State University

My first visit to Barrow and the Arctic Research Laboratory (before it became NARL) was in 1957. I was just finishing a trip across Northern Canada and Alaska in connection with research to be used for a dissertation dealing with snow, ice and permafrost.

At that time I determined that I would, in the years to come, do research on the Colville River Delta. This research, which is still ongoing, was started in 1961. It was in that year that I first became acquainted with numerous residents of Barrow including Pete Sovalik, Chester Lampe, Nelson Ahvakana, Kenny Toovak, and Harry Brower among others. At Nigilik on the Colville Delta (10 years before the establishment of Nuiqsut), I had the privilege of not only meeting but also working with several members of the George Woods' family. This association has continued to the present, although George and Nannie Woods are now deceased.



Nannie and George Woods at Nigilik,
1961

Between 1957 and 1996, I visited Alaska, the North Slope Borough and the Colville Delta in 21 separate years, sometimes twice. Since 1980 trips to the North Slope also involved work at Atkasuk, Point Lay, Wainwright and other locations. During those visits I had many opportunities for contact with citizens of the North Slope Borough including several of the North Slope Borough's mayors.

In 1961, Morris Morgan and I pitched our tent at Nigilik about 100 yards from George and Nannie Woods' home. Nannie was especially helpful. When the weather was bad, she would invite us into her house. During that season several interesting things happened; a few examples follow: Joeb Woods and I took his homemade boat out to Thetis Island which is about seven miles northeast of the Delta. While there, a storm came up and we headed back to the river. The waves were washing into the boat faster than I could bail. Becoming alarmed, I asked Joeb what we could do. His reply "hand me the sponge" told me more about his philosophy of life than any other comment or action during the subsequent 36 years we have known each other.

During the 1961 summer, I helped George, Nannie and Joeb pick their fishnets and prepare the white fish for drying. Nannie seemed to enjoy telling me about their fishing and other activities. During that summer Nannie made a number of caribou skin masks, several Eskimo yoyos and some mukluks for my wife. They have been used in many exhibits during the past 35 years.



George Woods and rack of drying whitefish at Nigilik, 1961. H. J. Walker Photo

On the last day of the 1961 field season, Joeb and I were coming back down the river toward Nigilik and spotted a caribou herd near the riverbank. As Joeb never lost an opportunity to get a caribou for this ice-cellar, we pulled up to the bank and on getting out of the boat, I asked Joeb if I could shoot one for him. He had gotten the idea that I didn't like guns (which was right) but gave me his gun anyway. I moved along the bank, rose up over the edge, and dropped the caribou in its tracks with one shot. Joeb was very surprised, as was I.

I went to the Colville again in 1962 with a fairly large team. Because Nannie had been so good to Morris Morgan and me in 1961, I took some cloth that Rita (my wife) had purchased and gave it to her. Apparently Nannie stayed up late that night sewing, because next morning she came out wearing the colorful outfit illustrated in the picture of her and George at the end of this essay.

During late winter in 1962, ARL hauled two cabins to the Delta placing them at Putu on top of the sand dunes at a location near the head of the Delta—a convenient location from which to do field work. Thus, we only occasionally went to Nigilik during 1962. However, on one occasion, Lydia Woods who had been in Anchorage for some time baked us a lemon chiffon pie, which was excellent. Subsequently, she married Jerry Sovalik and now lives in Nuiqsut.



NARL cabin at Putu, 1962.
H. J. Walker Photo

It was also in 1962 that George Woods had his run-in with what he called “my crazy caribou”. It seems that George was out gathering driftwood near Nigilik with an axe and this caribou charged him. Well George hit the caribou in the head, killing it. When the story got out, the head was taken in for examination and it was determined that the caribou was rabid. Rabid foxes were quite common in the Delta at the time.



Snow Traveller and Joe Woods at Putu, 1962.
H. J. Walker Photo

Also, in 1962, Pete Sovalik talked about fishing near Putu in winter. Instead of cutting several holes in the river ice he would tie a piece of ice to the end of his net—put it through one hole and give it a hard shove. Then from the second hole he would fish for it. Pete was especially helpful when it came to working up place names for the Delta, as were Nannie and Alice Woods. For example, in 1961 Pete Sovalik told me of the place called ‘kanak’ which was located on the right bank of the main channel opposite Putu and referred

to the undercuts that formed caves beneath the bank that could be used for protection. He mentioned that the blocks that broke off covering the 'caves' are called 'upkak'.

In 1962, I received letters from both George and Joeb Woods. A couple of items from these letters seem worth mentioning. Joeb wrote in February that "I don't think use my dogs this spring because I have now snow traveller" which was good news for me. He also noted that he had been in the hospital for nine days because "You know what, I shot myself with my pistol" and as a postscript added "when I shot, just lucky, miss my boon just on meat, don't worry about me I am alright now." George, in his letter dated December 21, 1962, wrote "I have caught 5 fat caribou while boys at Barrow. They are good meat...I am out of dried fish, very bad, like to have some."



Nuiqsut's first modern Naluqataq.

Early in the season of 1971, on a cold, snowy day we heard a knock at the door and it was Lucy Ahvakana who had just come from her property east of the Colville. She was full of information and told us many stories about polar bears. She also told us about the brown bear that had gotten into our cabin at Putu and apparently killed itself by biting into a large canned ham and swallowing the sharp tin. The bear's carcass had been removed before we arrived but the damage done to the cabin was quite evident including a broken mirror, which it had swiped with its paw.

In 1971, my wife Rita spent several weeks with me toward the end of the field season. We were taking measurements in the river and I wanted to get hourly measurements at both Putu and Nigilik. She went with Joeb to Nigilik and on the hour, every hour the two of them went out on the river to take measurements. Rita states that Nannie was especially good to her making sure she got warm every time she came in from the river. Nannie had a big fire going and plenty of blankets. During Rita's short stay Nannie fed her a number of delicacies including arctic char, muktuk and moose steak.

During my visits through 40 years, I had many occasions to see members of the Wood's family and to meet many other residents of Barrow, Wainwright and Nuiqsut. It was a pleasure to see people in Barrow whom I had met in the 1960s and to every-once-in-a-while meet someone who says, "Oh, yes, I worked on those cabins you used over on the Colville." Virtually every time I visit Barrow, I see Kenny Toovak and it is like old home week.



Nannie Woods at Barrow Naluqataq, two years before her death, 1987. H. J. Walker Photo

This short essay is dedicated to NANNIE WOODS, her family and all of the other people of the North Slope Borough who have made the past 40 years such an enjoyable and productive period of my life.

Jesse Walker, July 1, 1997

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**Presented to the North Slope Borough as a congratulatory message on the occasion of the
50th anniversary of the foundation of the Naval Arctic Research Laboratory.**



Mississippi State UNIVERSITY

Department of Geosciences
P. O. Drawer 5448
Mississippi State, MS 39762
Phone (601) 325-3915
FAX (601) 325-2907

May 15, 1997

Dr. John J. Kelly
School of Fisheries and Ocean Sciences
245 O'Neill
P.O. Box 757220
Fairbanks, AK 99775-7220

Dr. Kelly:

Enclosed is a letter to the people of the North Slope on the occasion of the 50th anniversary of the NARL. Dr. Jess Walker forwarded your letter requesting such a letter to me, as I was one of Jess' students in 1973. I hope you will include this letter in the presentation to the present mayor of Barrow in August. Thank you for the opportunity to contribute to this worthy event.

Charles L. Wax

A handwritten signature in cursive script that reads "Charles L. Wax".

Professor and Head



Mississippi State UNIVERSITY

Department of Geosciences
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Mississippi State, MS 39762
Phone (601) 325-3915
FAX (601) 325-2907

May 15, 1997

To the People of Barrow and the North Slope:

I wish to convey my congratulations on the event of the 50th anniversary of the NARL. I visited the North Slope through sponsorship from NARL in the summer research season of 1973 and completed field research for my M.S. thesis under the direction of Dr. Jess Walker. I subsequently completed both my M.S. and Ph.D. degrees at Louisiana State University. My experiences at the NARL, in Barrow, and in the Colville River delta region have been a highlight of my life, one that I reflect back on often. I use the pictures I took even now 24 years later, in classes I teach at Mississippi State University.

I remember only a few of the residents of the region, but those memories are good ones and are memories of people who treated strangers very well. I remember a lady named Nannie P. Woods who fed my fellow scientists and me our first taste of caribou steak. I also had the experience of watching the whole town bring in and dress a whale on the beach at Barrow. I tasted blubber and whale steak, quite an exotic treat for a young man from Mississippi! I also remember meeting and visiting often with a family named Sovalik. The father was Jerry and one of the children was Conrad. I taught the kids all about Shake-a-pudding, and they loved it.

I have never seen another landscape I found as thrilling as the Arctic. The experiences offered to me by the NARL and the North Slope are a one-in-a-lifetime chance, and I wouldn't give anything for having made the trip to your land and learning about the environment and the people. I congratulate you on maintaining the possibility for others to have similar experiences, and thank you profoundly for the adventure I had in your homeland. Barrow and the North Slope will always be a special place to me.

Charles L. Wax

Professor and Head

□

28 April 1997

Benjamin Nageak
Mayor
North Slope Borough
Barrow, AK

Dear Ben:

John Kelley has asked me to write a few words expressing to you and the many other Barrow-ites exactly what NARL has meant to me as an individual involved in sea ice research.

Although I had studied sea ice at various locations in the Canadian Arctic and out of Thule, Greenland since 1955, I first operated out of NARL in 1969 carrying out some sea ice sampling in the Beaufort Sea (in conjunction with Austin Kovacs and Gunther Frankenstein). As best I can recall I have worked off either the Chukchi or the Beaufort Coasts during 18 different winters. I was on the S.S. *Manhattan* cruises, on both AIDJEX pilot programs as well as on the main experiment, and for two winters operated the camp at Narwhal Island as part of the OCSEAP program. Much of our present knowledge concerning the distribution and properties of pressure ridges is based on work carried out in the near vicinity of Barrow as well as on data from laser profilometer flights deep into the Chukchi and Beaufort Seas carried out in NARL aircraft. In addition, our current understanding of the highly variable radar returns from ice covered lakes is all built on comparisons between aircraft and satellite SAR data and field observations on frozen lakes in the vicinity of Barrow. In the recent past (1989-94), I have continued to work jointly with Lew Shapiro on ice properties in the Barrow area collecting samples both within Elson Lagoon and off the Chukchi coast. In this work we used the NARL cold rooms to complete our mechanical tests.

How did NARL fit into all of this? It provided comfortable accommodations, excellent food courtesy of Tiny and George, laboratory space for carrying out salinity measurements plus cold rooms where laboratory-type tests could be carried out under controlled conditions on real sea ice samples. It also provided a chance to talk with other research groups operating in the same general area. In the 'old' days NARL could also be counted on to provide aircraft, shop and field support if this was scheduled well in advance. Recently this has not been the case after ONR abandoned the operation (ironically just prior to the time when they needed it most). However, this is not that much of a loss in my view in that it requires projects to be self-contained and to face up to the true costs of a given operation. In addition, many items that were in short supply at NARL in the old days can now easily be purchased at the local hardware store. In short, times have changed in many ways as you well know.

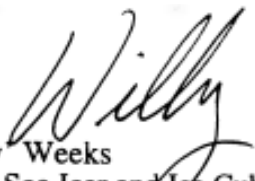
NARL has always been very good to individuals in my specialty in that there was one thing that it could invariably be counted on to produce: first-year sea ice with a dazzling array of structures and properties. Occasionally even some multiyear ice would be included at no extra cost. Furthermore, even if you messed everything up one winter, the ice would be back good as new the next year.

So I would like to thank everyone involved for allowing me to have all this fun and to write all those papers, which only my graduate students ever read [they were required to read them (or else)]. I would

particularly like to thank the following individuals, some of whom are unfortunately no longer among us, for assistance above and beyond the call of duty and for wise council on matters Arctic: Kenny Toovak, Ron MacGregor, Warren Denner, Raymond and Carl, Frankie Akpik, Barbara Harrison, Sis (Diane Dronenberg), Betty Dickerson, Dick Dellafield, Pat Walters, Buster Points and his amazing aluminum pterodactyl, Mike Frank, Arnie Hanson, Frenchy and Nicole, Jumper Bitters, Larry Underwood and last, but not least, a special thanks to the great Shipwreck Kelly, the King of Narwhal Island who was invaluable to our operations there, and to Richard Glenn, the man who always gets the job done and knows what he is doing; a rare combination. Ladies and gentlemen, I salute you.

I would also like to thank the residents of Barrow for their friendship, their continuing support of the science of the Arctic and for putting up with me over these many years even if I don't like muktuk. Finally I would like to thank you, Mr. Mayor, for many pleasantries and advice given over the years.

Sincerely,


W. F. 'Willy' Weeks
Unrepentant Sea Icer and Ice Cube-ologist
Professor of Geophysics Emeritus
University of Alaska Fairbanks

6533 SW 34th Ave.
Portland OR 97201-1077

28 March 1997

Congratulation UIC-NARL for the 50th Anniversary

My first experience with NARL was in the late 1960's. I was the principal investigator of the McCall Glacier project and asked NARL for logistics support, which they provided willingly. I still remember well my first visit there, the tundra, the Arctic Ocean and the indigenous people, a totally new experience for me as I recently arrived from Austria. Max Brewer, the steadily pipe-smoking director, surrounded by secretaries and support staff, was not easily approachable for a young scientist. He gave us, however, great support and our supplies were successfully air-dropped on the glacier.

One of the more difficult problems we faced was a snow machine (Ski-Doo Alpine), which we wanted to bring to the glacier. This machine was too heavy to be air-dropped. Hence, with two Eskimos as guides, we (C. Fahl, G. Weller and I) drove these from Barter Island to the McCall Glacier. This was a very interesting trip, and the knowledge of the indigenous people impressed me. When the fog rolled in, I always lost my bearing. Our native leaders never hesitated even without using a compass, and when the fog lifted we could see that we were always on the correct course. Years later I learnt they used the *sastrugi* direction for navigation.

Since these early days, I have been many times in Barrow, especially in connection with radiation measurements. I would like to acknowledge especially the great support of Dr. John Kelley, a later director of NARL, who made these trips very pleasant.



Gerd Wendler, ph.D.
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□

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WILLIAM RANSOM WOOD
 PRESIDENT (EMERITUS), UNIVERSITY OF ALASKA
On The Fiftieth Anniversary of NARL



My association with the work of the Naval Arctic Research Laboratory during the thirteen years I served as president of the University of Alaska, 1960-1973, was an exciting, challenging, and deeply satisfying learning experience.

At Barrow I met fine resident folk of the Arctic and came to appreciate their intimate knowledge of the north country and its traditional as well as current ways. They were at home in an extraordinarily demanding environment and happily making the most of it, proud, intelligent, and competent. Their individual and collective contribution to the advancement of science of the Arctic was substantial and continues to be so. They were and are keen observers and very practical problem solvers.

At Barrow and Fairbanks I was privileged to know several of the great scientists working on arctic research at the time. Dr. Eric Hultén, Dr. William Steer, Dr. Frank Pitelka, and Dr. Max Britton come to mind among many. At one summer gathering at NARL in the mid-sixties it was said that about ninety percent of all active arctic research scientists of the world, except Soviet Russia, were on hand. It was a memorable occasion.

For many years NARL was America's only "window on the Arctic." While its thrust was entirely scientific, it served secondarily an intelligence function for defense purposes.

Basically NARL's mission was service oriented. It provided supply and support for scientists and their research prospects under the general auspices of the University. These projects as well as the operation of NARL facilities received strong support from the Air Force, the office of Naval Research, and other agencies of government. The work was international in scope with participants from most circumpolar countries of the "Free World."

The story of success of NARL under the strong leadership of such dedicated Arctic Veterans as Max Brewer, John Schindler, and John Kelley is history. Work at T-3, the Ice Island Stations, the Man in the Arctic Program, the under the icecap exercises, as well as terrestrial observations has advanced knowledge of the north, the place and its people. It has been recognized as playing a crucial role in world affairs. NARL was timely and effective.

Its contribution to the future well-being of mankind has been quite worthwhile. The significance of the work accomplished through the "window of the north" merits celebration. The Fiftieth anniversary ceremonies are an appropriate tribute to all who participated in a notable and successful endeavor.

Respectfully,

William Ransom Wood
 President (Emeritus)
 University of Alaska

National Arctic research policy is essential

Daily News-Miner, Fairbanks, Alaska, Wednesday, Dec. 9, 1981



William R. Wood

Some months ago I wrote of "the growing chorus of voices . . . both in Alaska and at the national level favoring increased attention to Arctic research." The sound has not subsided, yet positive forward action on an idea of very real importance both to the nation and to Alaska remains elusive.

"The Arctic Research and Policy Act of 1981" seems stalled in the Senate where it originated. It is a partial advance at best, in fact, more of an effort to stabilize with a different funding approach the somewhat minimal present effort scattered among a variety of federal agencies, all of which are under heavy budget pressures.

Recently a hearing was held on the West Ridge campus of the university here concerning the continued maintenance and operation of the Naval Arctic Research Laboratory at Point Barrow. There was much support voiced for NARL based upon its long record of outstanding service, but no one came forward with a clear offer to fund the project annually with the several million dollars required.

Statements from more than one highly qualified scientist suggested that the very first step logically would be to set up a research policy and program for the Arctic. With such comprehensive decision established, then determine just how NARL as a major Arctic science support facility fitted into the total needs picture.

This makes good sense. Fortunately, renewed effort is under way on this long-discussed essential issue both at the national and state level. The United States urgently needs an Arctic research policy. It is long overdue. The Antarctic policy seems to work well for its very special purposes. It has been in place and decently supported for many, many years.

Alaska is being well represented on the highest level national scientific group that is now finalizing the wording of a basic Arctic Research Policy statement. Dr. Juan Roederer, head of the prestigious, world-recognized Geophysical Institute of the University of Alaska, is that representative; a stronger, more knowledgeable, more

concerned and dedicated advocate would be difficult to find. Earlier this month, speaking to the Fairbanks Chamber of Commerce, he electrified his audience with a forthright appraisal of the crucial role in world affairs of advanced research conducted in Alaska. Successful applications of today's most advanced science and technology required for national as well as state purposes in Alaska must be undertaken and tested in Alaska. Conditions cannot be simulated satisfactorily elsewhere. Certain basic knowledge of world significance can be advanced here and only here.

Clearly, not only must there be a

strong national policy on Arctic research, but also there must be established a program of research in Alaska based upon an Alaskan policy and commitment.

Again, fortunately, both the leadership and the machinery to do this are available in place. The Alaska Council on Science and Technology is active and well-equipped to accomplish the essential tasks. The council is headed by Nome-born, Alaska- and Cal Tech-educated Dr. Neil Davis, a distinguished scientist for many years at the Geophysical Institute. He is retiring, we understand, from the university to devote full time to the urgent developmental tasks of the Alaska Council on Science and Technology. The message here is to move promptly at a much faster pace than the old dictum, "with all deliberate speed," implies.

The hard nut to crack of course, in all this is adequate financial support. The issue is both national and state. There is also an important funding role for the private sector to play. At this critical

juncture, however, the state of Alaska must take the lead in developing and funding a comprehensive Alaska Research Program. Put simply this is the advancement and application of knowledge of high latitudes—the A-OK thrust.

The minimum funding requirement in terms of 1982 dollars is not less than \$100 million annually to be used in Alaska and the adjacent high north.

The state Permanent Fund board of directors seeking sound investment opportunities should really act favorably on this one. Obviously the board members are deeply concerned with the future prospects of the people whose discretionary wealth they are charged with managing prudently. Investment in a sound comprehensive Arctic research program qualifies as the one long-term comparatively risk-free opportunity. Why not dedicate a small fraction of the income from the Permanent Fund to guarantee the future of Alaska and its people to the fullest extent humanly possible? Makes the very best of good common sense.

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